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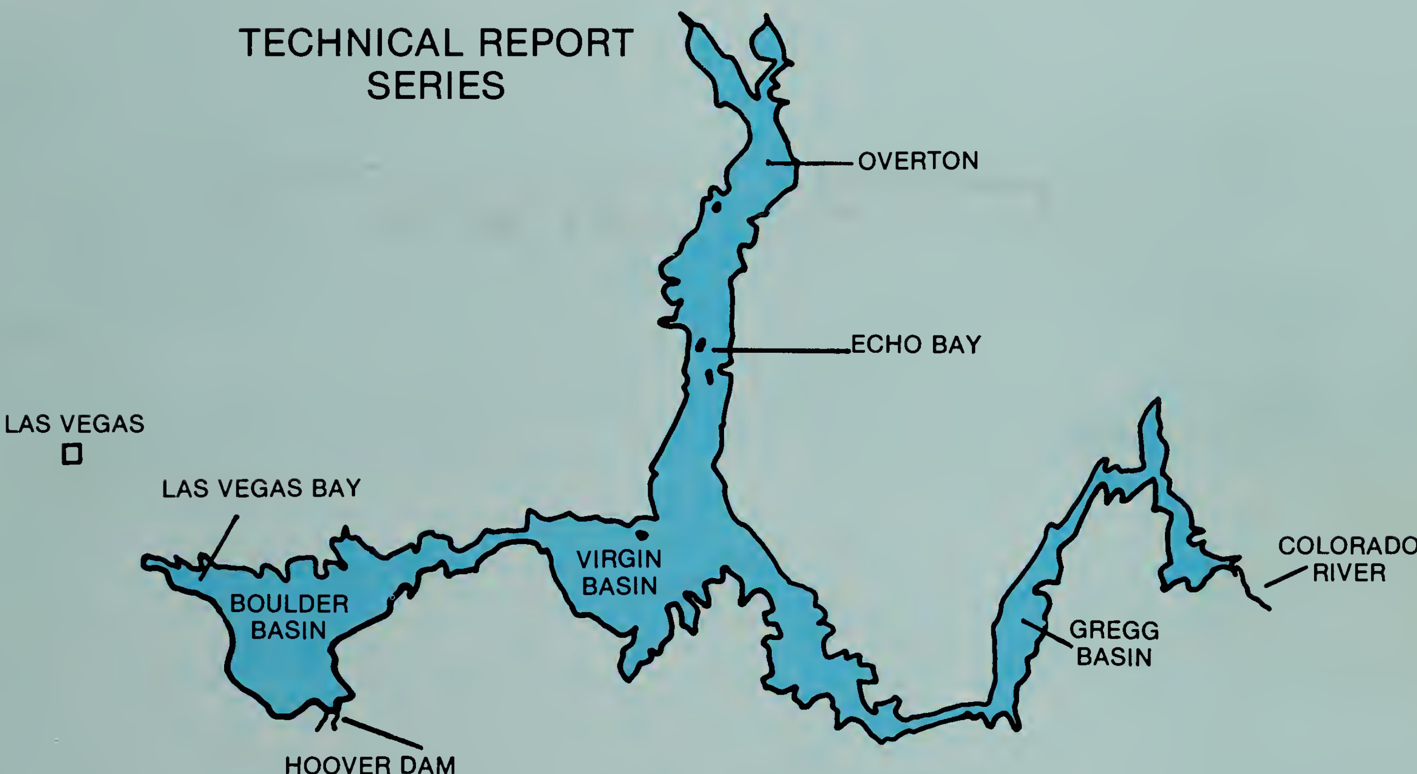
LAKE MEAD LIMNOLOGICAL RESEARCH CENTER

THE LIMNOLOGY IN RESERVOIRS ON THE COLORADO RIVER

Larry J. Paulson and John R. Baker

Technical Report No. 11

TECHNICAL REPORT SERIES



DEPARTMENT OF BIOLOGICAL SCIENCES
UNIVERSITY OF NEVADA
LAS VEGAS

The Limnology in Reservoirs on the Colorado River

Larry J. Paulson and John R. Baker

Technical Report No. 11

Lake Mead Limnological Research Center

Department of Biological Sciences

University of Nevada, Las Vegas

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1.0 INTRODUCTION

1.1 Water Quality in the Colorado River

The hydroelectric dams on the Colorado River impound water in a series of main stem reservoirs (Lake Powell, Lake Mead, Lake Mohave and Lake Havasu) that comprise one of the largest and most heavily used freshwater systems in the nation. The reservoirs provide for river regulation and flood control; agricultural, municipal and industrial water supplies; power generation; recreation (fishing, swimming, camping) and wastewater disposal. The revenues generated by those uses makes the Colorado River the most valuable water resource in the southwest. This value will further increase as demands for water resources rise with continued urban and agricultural development in the basin. Management of the system will become increasingly more complex as the effects of various uses are manifest in changes to water quality of the river.

Water quality in the Colorado River was viewed largely in terms of the silt and salt concentrations of agricultural water supplies during early development in the basin. Those are still important water quality parameters (USDI 1982), but recently concern for water quality has been enlarged to include a consideration of the nutrient and trophic status of the reservoirs (EPA 1978a, b, c, d). This is especially evident in Lake Mead where considerable research has gone into establishing appropriate water quality criteria for effluent discharges from Las Vegas Wash (Deacon and Tew 1973; Deacon 1975, 1976, 1977; Goldman 1976; Brown and Caldwell 1981). To a large extent, these

SILT
SALT
NUTRIENT
LAKE POWELL

additional water quality criteria have evolved with increased demands for recreational and municipal uses of the reservoirs and river. Increased emphasis on reservoir nutrient and trophic status clearly is justified because of the influence that these parameters have on various uses. Excessive nutrient concentrations and phytoplankton productivity can degrade water clarity for recreation; contaminate municipal water supplies; foul canals, aqueducts and pipelines and deplete oxygen concentrations in the metalimnion and hypolimnion of the reservoirs. Conversely, low nutrient concentrations and productivity can limit the food base available to support the valuable sport fisheries. Management agencies thus are faced with solving a variety of potential problems that are directly related to reservoir nutrient and trophic status.

The comprehensive limnological data required to evaluate current water quality or to develop effective water quality management programs for the future are limited for the Colorado River reservoirs. This study was authorized to conduct basic limnological studies in Lake Powell, Lake Mead, Lake Mohave and Lake Havasu. The principal objectives of the investigation were to (i) measure nitrogen and phosphorus loading and loss rates for each reservoir, (ii) measure nutrient concentrations and phytoplankton productivity in each reservoir, (iii) determine how the reservoirs interact to influence water quality of the river and (iv) evaluate how reservoir nutrient and trophic status are related to the operations of the dams.

The research on which this report is based was supplied in

part by the U.S. Department of the Interior under PL 95-467 (Project B-121-Nev. Contract No. 14-34-0001-1243) and in part by the Four Corners Regional Commission, the Nevada Department of Wildlife, the Bureau of Reclamation, Lower Colorado River Region and the Lake Mead Limnological Research Center.

1.2 Related Studies in the Colorado River

The early research on the Colorado River was devoted primarily to defining siltation rates (USDI 1960), circulation patterns (USDI 1941, 1947; Anderson and Pritchard 1951), evaporation (Harbeck et al. 1958) and salt leaching in Lake Mead (USDI 1960). Those studies have been concisely summarized by Thomas (1954) and Hoffman and Jonez (1973) in case history reviews of the reservoir.

THOMAS 1954
HOFFMAN JONEZ 1973

Biological studies were first started in Lake Mead during 1941 to evaluate problems with the largemouth bass *(Micropterus salmoides)* fishery (Moffet 1943). Subsequent fisheries investigations were made in Lake Mead by Wallis (1951) and below Hoover Dam by Moffet (1942) and Dill (1944). The first comprehensive reservoir investigations were conducted by Jonez and Sumner (1954). Those studies were conducted to evaluate fisheries problems in Lake Mead and to assess the sport fisheries potential in Lake Mohave. However, some limnological data were also collected in their investigations.

A basin-wide water quality investigation was conducted in the Colorado River during 1966 (FWPCA 1968). The purpose of that study was to identify pollution sources along the river system.

A series of water quality surveys were subsequently conducted in Lake Mead during the late 1960's and early 1970's (FWPCA 1967; Hoffman et al. 1967; EPA 1971; Hoffman et al. 1971) to evaluate the effects of effluent discharges from Las Vegas Wash on water quality in Las Vegas Bay. Those surveys were followed by more detailed investigations of the interactions among physical, chemical and biological factors in Las Vegas Bay (Deacon and Tew 1973; Deacon 1975, 1976, 1977; Goldman 1976; Baker et al. 1977; Brown and Caldwell 1981; Baker and Paulson 1981). Reservoir-wide limnological studies also were conducted in Lake Mead during 1971 (Everett 1972) and 1977-78 (Paulson et al. 1980). A sediment survey was done in Lake Mead during 1979 to evaluate historical changes in productivity (Prentki et al. 1981; Prentki and Paulson 1983). We recently completed a two year investigation, of which this study was an integral part, of the interrelationships among nutrients, plankton and striped bass in Lake Mead (Paulson and Baker 1983).

The other main stem reservoirs have not been studied as comprehensively as Lake Mead, but some limnological investigations have been conducted in each reservoir. The NSF Rann program on Lake Powell resulted in descriptions of the circulation patterns (Merritt and Johnson 1977; Johnson and Merritt 1979) nutrient loading and cycling (Mayer 1977; Mayer and Gloss 1980; Gloss et al. 1980; Gloss et al. 1981), oxygen depletion (Johnson and Page 1980) and rates of productivity (Hansmann et al. 1974). A limnological survey was conducted in Lake Mohave and Lake Havasu in the summer of 1971 (Portz 1975). We made extensive limnological studies in Lake Mohave during

AKE POWELL BASICS

1976 and 1977 (Priscu 1978, Paulson et al. 1980; Priscu et al. 1980; Priscu et al. 1982). Minckley (1979) also made some limnological measurements in Lake Mohave and Lake Havasu during a fisheries survey of the lower river.

2.0 DESCRIPTION OF THE STUDY AREA

2.1 General Description

The study area encompassed a 1123 km reach of the Colorado River that extends from the headwaters of Lake Powell to Parker Dam (Fig. 2.1). The four reservoirs occupy about 660 km of this reach. Lake Mead and Lake Powell are large storage reservoirs with a combined capacity of 52.4 million acre-feet in active storage (Table 2.1). The reservoirs serve primarily for river regulation, flood control and power generation. Lake Mohave and Lake Havasu are typical "run of the river" reservoirs and have a combined capacity of 2.4 million acre-feet (Table 2.1). Lake Mohave serves primarily for reregulation of releases from Hoover Dam and for power generation. Lake Havasu is used to create additional storage for the Metropolitan Water District diversions through the California Aqueduct near Parker Dam and for power generation. It will also serve as the diversion point for the Central Arizona Project when it is completed in 1985.

[The principal inflows to Lake Powell are the Colorado River, Green River and San Juan River. The Colorado River inflow is unregulated above the confluence with the Green River. The Green is regulated by Flaming Gorge Dam and the San Juan River by Navajo Dam.] Discharges from Glen Canyon Dam, through the 450

* Regulation
LAKE POWELL
INFLOWS

GREEN
SAN JUAN
FLAMING GORGE DAM
NAVAJO DAM

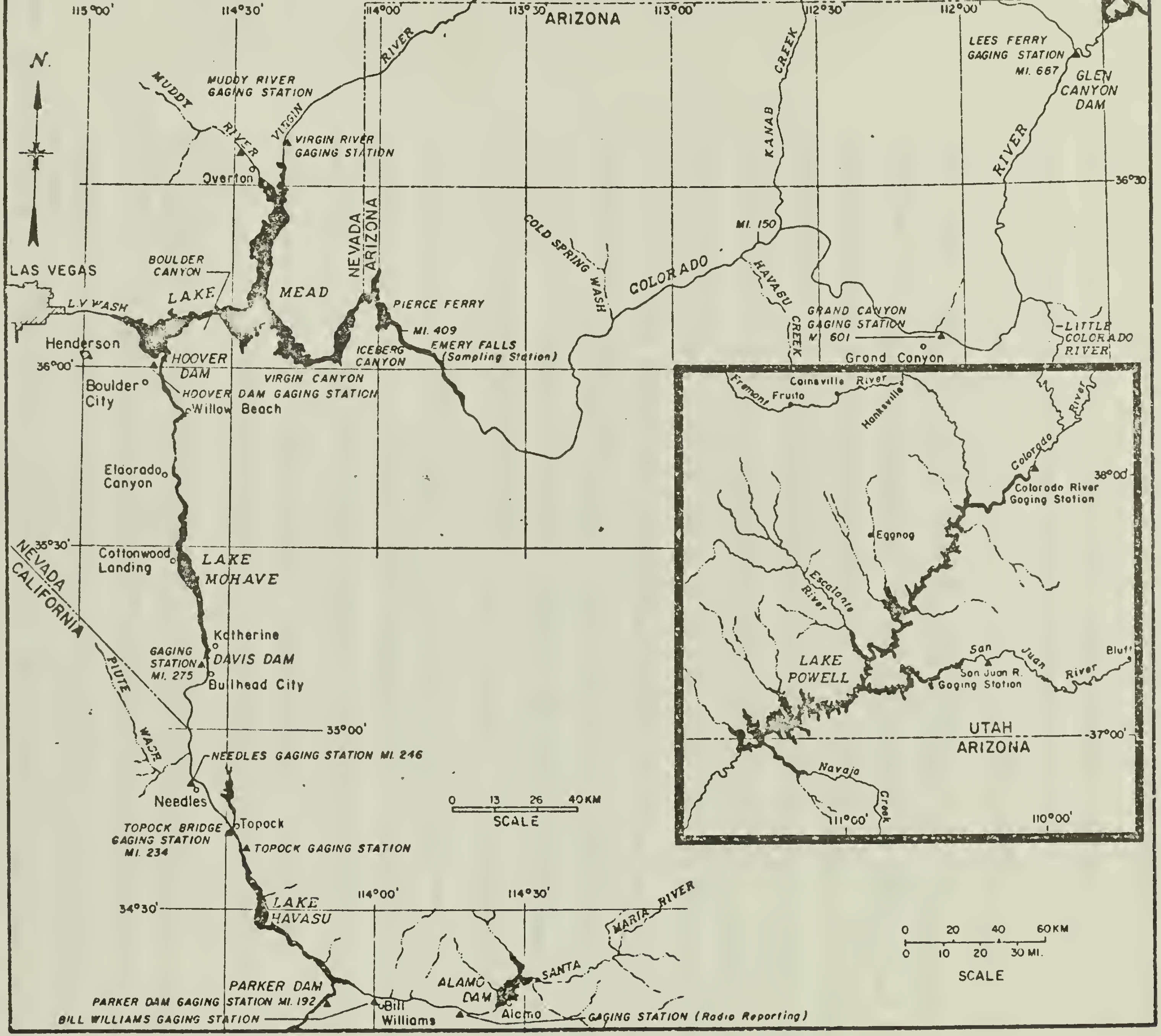

Figure 2.1 The Colorado River System from headwaters of Lake Powell to Parker Dam.

Table 2.1. Morphometric characteristics of the Colorado River reservoirs (derived from Lara and Sanders (1970); Hoffman and Jonez 1973; Johnson and Merritt 1979; and U. S. Bureau of Reclamation).

Parameter	Reservoir			
	Lake Powell	Lake Mead	Lake Mohave	Lake Havasu
Maximum Operating Level (m)	1128.0	374.0	197.0	137.0
Maximum Depth (m)	171.0	180.0	42.0	25.0
Mean Depth (m)	51.0	55.0	19.5	9.6
Surface Area (km^2)	653.0	660.0	115.0	83.0
Volume ($m^3 \times 10^9$)	33.0	36.0	2.3	0.8
Maximum Length (km)	300.0	183.0	108.0	65.0
Maximum Width (km)	25.0	28.0	6.4	5.0
Shoreline Development	26.0	9.7	3.0	-
Discharge Depth (m)	70.0	83.0	42.0	15.0
Annual Discharge ($m^3 \times 10^9$)*	10.0	9.7	9.1	8.2
Retention Time (yr.)	3.3	3.7	0.2	0.1

* Averages for 1981 and 1982

km reach in Grand Canyon, comprise the principal inflow to Lake Mead. Discharges from Hoover Dam, via a 27 km reach in Black Canyon, are the only inflows to Lake Mohave. Lake Mohave backs up into the tailrace of Hoover Dam during winter months when it is at full capacity. Discharges from Davis Dam, through a 68 km river reach between the dam and Topock Bridge, comprise the main inflow to Lake Havasu.

2.2 Lake Powell

Lake Powell was formed by the construction of Glen Canyon Dam in 1963. It is located on the Colorado Plateau of northwestern Arizona and southwestern Utah. Lake Powell extends 300 km from the lower end of Cataract Canyon through most of Glen Canyon to the dam site at Page, Arizona (Fig. 2.2). The San Juan Arm, located approximately midway in the reservoir, extends 90 km to the east. The reservoir is narrow and extremely irregular (SLD=26) having steep canyon walls and numerous side canyons.

Lake Powell is a deep storage reservoir with a maximum depth of 171 m. It is the largest reservoir in the United States in terms of surface area and is second to Lake Mead in terms of volume (Table 2.1). The discharge from Glen Canyon Dam is in the hypolimnion at 70 m. Discharge temperatures average about 8-9^{o}C.

The principal inflows to Lake Powell are the Colorado River and the San Juan River which represent 88% and 10% of the total annual inflow, respectively. Approximately 60% of the annual

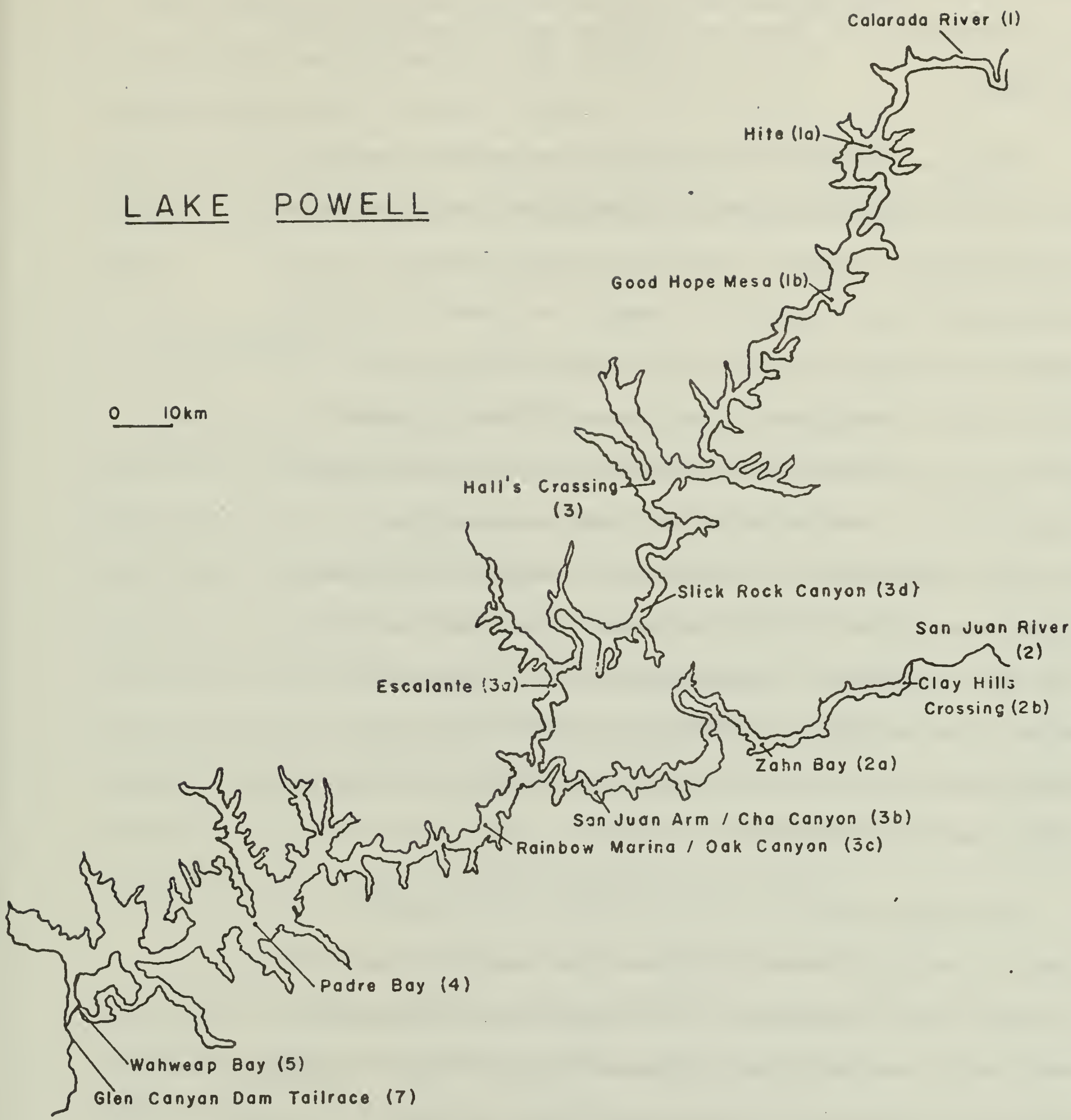

Figure 2.2 Map of Lake Powell showing locations of sampling stations.

inflow occurs in the spring (April-July) due to snow melt (Gloss et al. 1981). Other minor inflows are the Escalante River and the Dirty Devil River. There are no major water diversions from Lake Powell.

Geological features of Glen Canyon from the upper strata down are: Cretaceous straight cliffs sandstone, tropic or mancos shale and Dakota sandstone; Jurassic Morrison formation; the San Rafael group of bluff sandstone, Summerville formation, Entrada sandstone and Carmel formation; the Jurassic-Triasaic Glen Canyon group of Navajo sandstone, Kayenta formation, Muenave formation and Wingate sandstone; the complex middle and lower Triassic Chinle formation with the lowest member of the Shinarump conglomerate and the Moenkopi formation; the Permian Cutler formation of white rim sandstone, Organ Rock sandstone, Cedar Mesa sandstone and Halgaito tongue: the transitional marine to non-marine Rico formation; and finally the Pennsylvanian Hermosa formation and the gypsiferous Paradox beds (Potter and Pattison 1976).

The climax vegetation in most of the area around Lake Powell is the blackbrush association. Mesa vegetation occurs at the head of the tributaries or in large coves with permanent water seeps. The vegetation is dominated by coyote willow (Salix exiqua), black willow (S. goodinquin), Emory baccharis (Baccharis emorusi), arrowweed pluchea (Chuercus gambelii), netleaf hackberry (Celtis reticulatar) and Fremont cottonwood (Populus fremontii) (Potter and Pattison 1976). The dominate pioneer vegetation along the sandy or silty shorelines is salt

cedar (*Tamarix penthandra*).

The climate is arid with annual precipitation averaging 12 cm. The average maximum summer (July) temperature is 27^{o}C and the average winter (January) minimum is -1^{o}C. Strong continuous winds are common from February through May. The fall and early winter periods are generally calm (Potter and Pattison 1976).

2.3 Lake Mead

Lake Mead is located in the Mojave Desert of southeastern Nevada and northwestern Arizona 15 km northeast of Las Vegas, Nevada. The reservoir was formed in 1935 by construction of Hoover Dam. Lake Mead extends 183 km from the mouth of the Grand Canyon (Pierce Ferry) to Black Canyon, the site of Hoover Dam (Fig.2.3). Lake Mead is comprised of four large basins: Boulder, Virgin, Temple and Gregg Basin, interspersed with four narrow canyons: Black, Boulder, Virgin and Iceberg Canyon. The reservoir is bordered by the Muddy and Frenchman Mountains on the north and the Virgin and Black Mountains on the south.

In terms of volume, Lake Mead is the largest reservoir in the country and second only to Lake Powell in surface area. The shoreline is irregular (SLD = 9.7) and includes several large bays (Las Vegas and Bonelli) and numerous coves. The reservoir has a short hydraulic retention rate (3-4 years) due to the great inflow from the Colorado River. The mean depth is 55 m (Table 2.1). The discharge from Hoover Dam is in the hypolimnion at 83 m depth (at operating level of 364 m).

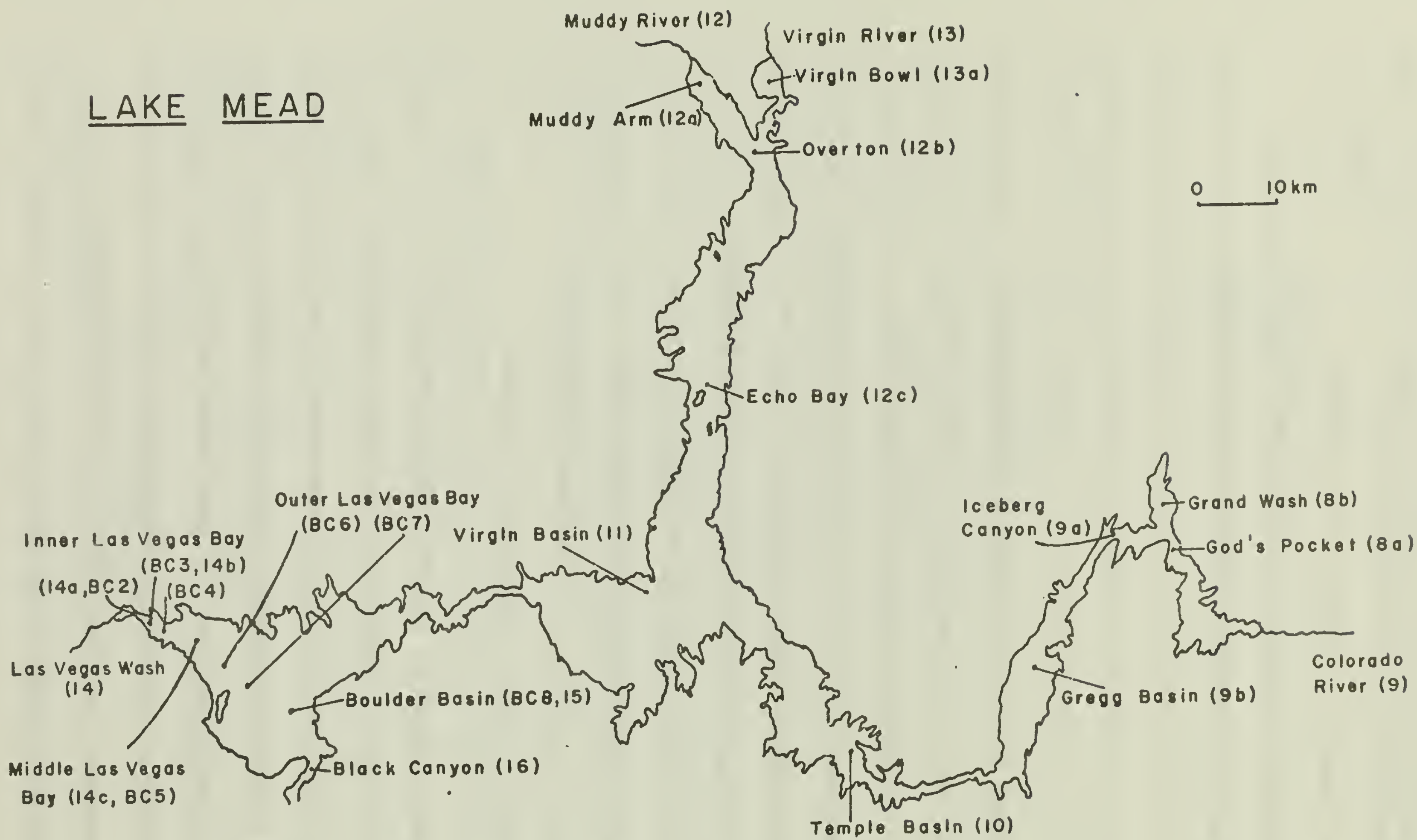

Figure 2.3 Map of Lake Mead showing locations of sampling stations.

The principal water inflow to Lake Mead is derived from the Colorado River (90%). The Virgin and Muddy Rivers, which discharge into the Overton Arm, and Las Vegas Wash, which discharges into Las Vegas Bay, also contribute year-round inflows. There is only one principal water diversion from Lake Mead. This is located at the Southern Nevada Water Project, Saddle Island, where municipal, irrigation and industrial waters are diverted to the Las Vegas metropolitan area.

The predominate geological features of the Lake Mead floor and surrounding area are the sedimentary deposits of the Muddy Creek formation that were formed during the Paleozoic and Mesozoic eras (Longwell 1936). These deposits consist of moderately consolidated sand, silt and clay. There are also layers of shale, sandstone and limestone interspersed with beds of gypsum, anhydrite and rock salt (Longwell 1936). Deposition of fine silt material since formation of the reservoir has altered the original floor of Lake Mead. Up to 25 m of silt material was deposited in the upper reaches of the reservoir before Lake Powell was formed in 1963 (Lara and Sanders 1970).

The vegetation surrounding Lake Mead is comprised primarily of salt cedar (*Tamarix gallica*) and creosote bush (*Larrea tridentata*) . Emergent macrophytes are rare, but some coves contain a few isolated stands of cattails (*Typha* sp.) and sedges (*Scirpus* sp.). Submergent macrophytes are also rare, but *Potomogeton pectinatus* and *Najas* sp. occur sporadically in shallow coves.

The climate is arid with annual precipitation averaging

about 8 cm. Mean annual temperature is about 19°C with a range from 45°C in the summer down to -1°C in the winter. Winds are highly variable, but generally, southerly winds prevail in the summer compared to north-easterly winds in the winter.

2.4 Lake Mohave

Lake Mohave is located 120 km south of Las Vegas, Nevada. The western side of the reservoir is located in Nevada and the eastern side in Arizona. The reservoir was formed in 1950 by construction of Davis Dam. Lake Mohave extends 108 km south from Hoover Dam to Davis Dam (Fig. 2.4). Lake Mohave has two small basins, Eldorado and Little Basin at the upper end and Cottonwood Basin located in the middle of the reservoir. The reservoir is bordered by two discontinuous mountain ranges. The first 27 km, which are located in Black Canyon, are bordered by the Black Mountains to the east and the Eldorado Mountains to the west. The Black Mountains continue to parallel the east side of the reservoir, but the Eldorado Mountains join the Newberry Mountains on the west side near Davis Dam.

Lake Mohave is small in terms of volume and surface area by comparison with Lake Powell and Lake Mead (Table 2.1). It also has a more regular shoreline (SLD = 3.0) and contains few coves or bays. The hydraulic retention time for Lake Mohave is only .20 year due to rapid flushing by the Colorado River. The discharge at Davis Dam originates from the hypolimnion near the bottom. The only significant inflow to Lake Mohave is from the Colorado River via discharges from Hoover Dam. The Willow Beach

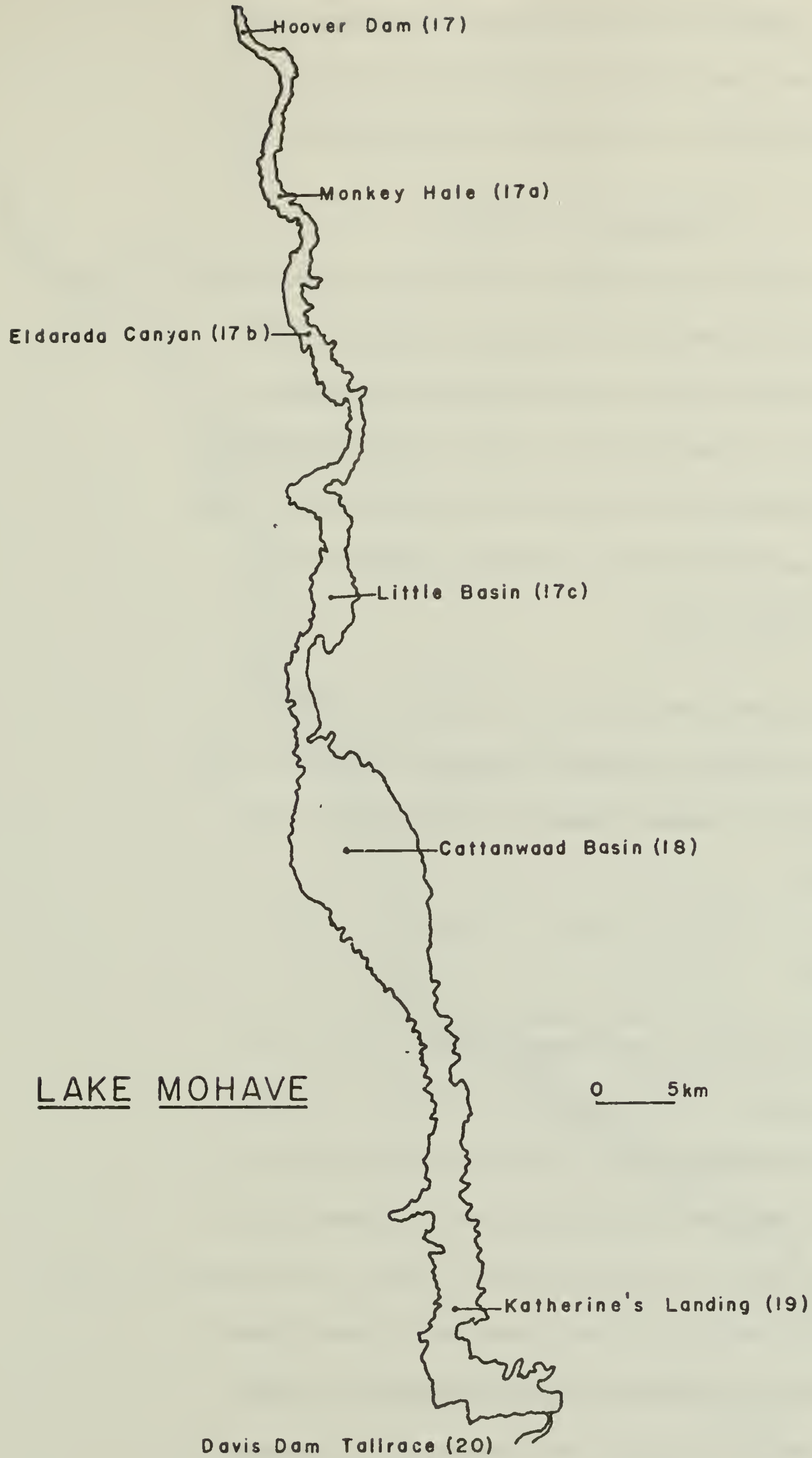

Figure 2.4 Map of Lake Mohave showing locations of sampling stations.

Trout Fish Hatchery, located 18 km downstream from Hoover Dam, discharges some effluent, but this is insignificant relative to the Colorado River. There are no major diversions of water from Lake Mohave.

The Lake Mohave floor is comprised primarily of clay, silt and sand deposits of the Chemheovis formation (Longwell 1936). Alluvial deposits brought in by runoff from the surrounding mountains also comprise a large portion of the bottom substrate. Although the upper reservoirs now trap most of the sediment from the Colorado River, Lake Mohave still contains remnant silt deposits from the Colorado River.

The vegetation around Lake Mohave is similar to Lake Mead, except that stands of mesquite (*Prosopis odorata*) and palo verdi (*Cercidium* sp.) are more common. Climate conditions are also similar to Lake Mead.

2.5 Lake Havasu

Lake Havasu is located in the Sonoran Desert along the Arizona-California border. The reservoir was formed in 1938 by the construction of Parker Dam. The upper end of the reservoir is 20 km southwest of Needles, California and it extends south 84 km to the mouth of the Bill Williams River (Fig. 2.5). The reservoir is generally narrow with only one basin area located midway in the reservoir. In terms of surface area and volume, Lake Havasu is the smallest of the four reservoirs. The depth of the reservoir does not exceed 10-15 m except at the dam.

The Colorado River provides 99% of the total annual inflow,

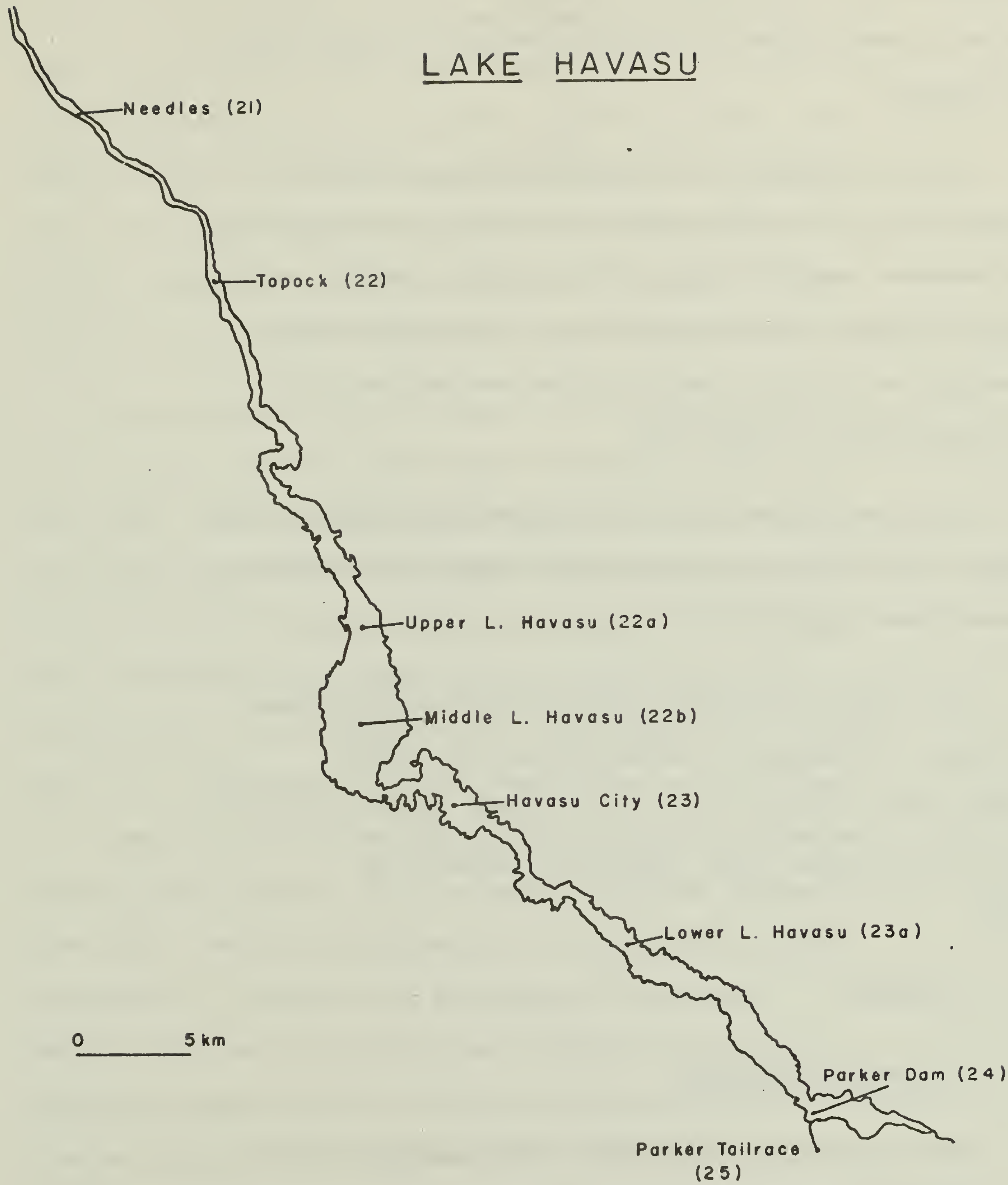

Figure 2.5 Map of Lake Havasu showing locations of sampling stations.

but the Bill Williams River also contributes year-round inflows. Water diversions from the reservoir are made at the California Aqueduct located approximately 3 km above Parker Dam. The Central Arizona Project is located in the Bill Williams Arm of the reservoir.

The area consists of fault-block mountain ranges with intervening alluvium-filled basins (USBR 1973). The upper end of the reservoir has the Chemetluevi Mountains to the west and the Mojave Mountains to the east. The lower end has the Whipple Mountains and Buckskin Mountains to the west and the Bill Williams Mountains to the west.

The desert in the area of Lake Havasu is a transition zone between the Sonoran and Mojave Deserts. Vegetation is typically Sonoran Desert (USBR 1973).

The climate of the area is typical of the Sonoran Desert with long, hot summers and short mild winters. Annual precipitation averages 13 cm. Average summer temperature (July) is $34^{o}C$ and average winter temperature (January) is $10^{o}C$.

3.0 METHODS

3.1 Sampling Locations

Sampling stations were located in the principal inflows mid-channels, embayments or arms and tailraces of each reservoir (Figs. 2.2 - 2.5). The inflow stations included the Colorado River in Cataract Canyon (1) and the San Juan River (2) on Lake

Powell (Fig. 2.2); the Colorado River below Separation Rapids (9), Virgin River (13), Muddy River (12) and Las Vegas Wash (14) inflows to Lake Mead (Fig. 2.3). The Hoover Dam outflow (17) forms the principal inflow to Lake Mohave (Fig. 2.4), and the Davis Dam outflow is the main inflow to Lake Havasu (Fig. 2.5). Sampling stations were also located at Needles (21) and Topock (22) in the reach between Davis Dam and Lake Havasu. The tailrace samples were collected immediately below Glen Canyon Dam (7), Hoover Dam (17), Davis Dam (20) and Parker Dam (25).

The mid-channel stations in Lake Powell were located at Hite (1a), Good Hope Mesa (1b), Halls Crossing (3), Slick Rock Canyon (3d), Escalante (3a), Rainbow Marina (3c), Padre Bay (4) and Wahweap Bay (5) (Fig. 2.2). Stations were also located in the San Juan Arm at Zahn Bay (2a) and Cha Canyon (3b). In Lake Mead, mid-channel stations were located at God's Pocket (8a), Iceberg Canyon (9a), Gregg Basin (9b), Temple Basin (10), Virgin Basin (11), Boulder Basin (15) and above Hoover Dam (16) (Fig. 2.3). Sampling stations were also located in the Overton Arm at Echo Bay (12c), Overton (12b), Virgin Bowl (13a) and the Muddy River (12a). The inner Las Vegas Bay (14a, BC3, BC4) and middle Las Vegas Bay (14c) areas were also sampled in the study. Sampling stations in Lake Mohave were located in the riverine section at Monkey Hole (17a) and at mid-channel areas of Eldorado Canyon (17b), Little Basin (17c), Cottonwood Basin (18) and Katherine's Landing (19) (Fig. 2.4). In Lake Havasu, stations were located in the mid-channel at upper Lake Havasu (22a), mid-Lake Havasu (22b), Havasu City (23), lower Lake Havasu (23a) and above Parker Dam (24) (Fig. 2.5).

3.2 Phytoplankton Productivity

Phytoplankton productivity was measured in situ with the ^{14}C method (Steeman, Nielson 1952; Goldman 1963). Productivity measurements were made at monthly intervals from February 1981-March 1982 at select locations in Lake Mead (9a, 9b, 10, 11, 12a, 12b, 13a, 14a, 14c and 15), Lake Mohave (17b, 17c, 18 and 19) and Lake Havasu (22b, 23a and 24). Bi-weekly measurements were also made at stations 14a, 14c and 15 in Lake Mead during the summer months (July-September).

Water samples were collected from 0, 1, 3, 5, 7, 10, 15, 20 and 25 m, or to the bottom at shallow stations. Samples were collected with a three-liter Van Dorn sampler and transferred to 125-ml glass-stoppered reagent bottles. Two light bottles and an opaque bottle from each depth were inoculated with 1 ml of a 1.0 Ci/ml $Na^{14}CO_3$ solution. The bottles were resuspended at the depth of collection and incubated for a three-four hour period during mid-day. Since several stations had to be sampled each day, synoptic incubations were used for stations where light transmittance was similar. Stations 14a, 14c and 15 in the lower basin of Lake Mead, 12a, 12b and 13a in the Overton Arm and 8b, 9a and 9b in the upper arm were incubated on location. Station 11 (Virgin Basin) was incubated at station 12c (Echo Bay) and station 10 (Temple Bar) was incubated at station 9b (Gregg Basin). In Lake Mohave, stations 17b and 17c were incubated on location and stations 18 and 19 were incubated at station 17b. All productivity samples in Lake Havasu were incubated at station 24.

After the incubation period the bottles were stored in light-proof ice chests and transported to the laboratory for processing. The entire contents of each bottle were filtered through .45μ membrane filters (47 mm dia.) at 100 mm Hg. The filters were rinsed with .005 N HCl to dissolve any carbonate residue embedded in the filters. Each filter was transferred to a 22 ml scintillation vial, allowed to dry and then filled with 20 ml of scintillation cocktail (two parts PCS:1 part Xylene). Radioactivity was measured with a Beckman LS-100 Scintillation Counter calibrated with a certified standard $Na^{14}CO_3$ solution.

In order to determine inorganic carbon, total alkalinity was determined on a water sample collected at the same depth as phytoplankton productivity. Temperature and pH were first measured, and a 50 ml sample was then titrated with a .02 N HCl to pH 4.8 (APHA 1975). Inorganic carbon was calculated from conversion tables of Saunders et al. 1962.

A pyroheliometer (Weather Master), placed in the vicinity of the sampling stations was used to record solar radiation during the incubation period. Incident solar radiation was determined by planimetry of the recording. Estimates of total daily solar radiation were obtained from the University of Nevada, Las Vegas, Biological Sciences Department or the Las Vegas Airport. Daily phytoplankton productivity was computed by extrapolation from the ratio of solar radiation during the day to solar radiation during the incubation period. Integral (areal) phytoplankton productivity (mg C/m^2/day) was

computed by trapezoidal integration of discrete depth interval measurements.

3.3 Chlorophyll-a

Chlorophyll-a concentrations were measured monthly at each reservoir sampling location and in the tailrace of Davis Dam and Parker Dam. Weekly or bi-weekly measurements were also made at the lower basin stations in Lake Mead during summer months (July-September). One-liter water samples were collected from a 0-2.5 m integrated sample at station 14a and a 0-5 m integrated sample at the other reservoir stations. Composite water samples were collected in the tailrace at a mid-depth in the water column with a three-liter Van Dorn sampler. The samples were stored in the dark in an ice chest and immediately transported to the field laboratory for processing. A 500-1000 ml subsample, depending upon phytoplankton densities, was treated with magnesium carbonate, filtered through glass fiber filters (GFC) at 100 mm Hg. and frozen. The filters were then ground in 3-5 ml of 90% acetone and the final volume brought to 10 ml. This was followed by a three-hour extraction period in the dark (Golterman 1969). The sample was then centrifuged and the supernatant decanted into 1 cm cuvettes. Absorbance readings were made at 750, 663, 645, 630, 510, 480 nm on a Perkin Elmer Model 552 Spectrophotometer. Chlorophyll- *a* concentrations were calculated according to the equations of Strickland and Parsons (1972).

3.4 Nutrient Analyses

3.4.1 Sample Collection and Preservation

Nutrient concentrations were measured monthly at each sampling location. Weekly or bi-weekly measurements were also made at the lower basin stations in Lake Mead during summer months (July-September). Water samples for nutrient analyses were collected from a 0-2.5 m integrated sample at station 14a and 0-5 integrated sample at the other reservoir stations. At deeper stations samples were also collected at 10 m, 25 m and 70 m with a Van Dorn sampler. Samples also were collected at 50 m and 90 m above Hoover Dam (station 16) and Glen Canyon Dam (station 5). Composite samples were collected at the inflow and outflow stations at a mid-depth in the water column with a three-liter Van Dorn sampler. Water samples for soluble nutrient analyses (ammonia, nitrate + nitrite and orthophosphorus) were filtered immediately through glass fiber filters (GFC or GFF). All samples were frozen and analyzed within one-two weeks after collection.

3.4.2 Ammonia

A 50 ml filtered subsample, or a suitable aliquot diluted to the range of sensitivity, was analyzed for ammonia with the phenol hypochlorite method according to the procedures of Solorzano (1969) as modified by Liddicoat et al. (1975). Absorbance readings were made at 640 nm in a 10-cm cuvette with a Perkin Elmer Model 552 Spectrophotometer.

3.4.3 Nitrate + Nitrite

A 50 ml filtered subsample, or a suitable aliquot diluted

to the range of sensitivity, was analyzed by the hydrazine reduction method first described by Mullin and Riley (1955) and later updated by Kamphake et al. (1967). Absorbance readings were made at 543 nm in a 5-cm cuvette with a Perkin Elmer Model 552 Spectrophotometer.

3.4.4 Total Nitrogen

A 50 ml unfiltered subsample, or suitable aliquot diluted to the range of sensitivity, was analyzed for total nitrogen according to the methods of D'Elia et al. (1977). Absorbance readings were made at 543 nm in a 1 cm curvette with a Perkin Elmer Model 552 Spectrophotomer.

3.4.5 Orthophosphorus and Total Phosphorus

Orthophosphorus and total phosphorus were determined using the ascorbic acid method described by Strickland and Parsons (1972) and APHA (1975). For total phosphorus, a 50 ml, unfiltered sample was treated with an ammonia persulfate solution to release phosphorus from particulate and dissolved organic matter. For orthophosphorus, a 50 ml sample was filtered through glass-fiber filters, prior to addition of other reagents. Absorbance readings were made at 645 nm in a 10-cm cuvette with a Perkin Elmer Model 552 Spectrophotometer. A more detailed description of our methods of nutrient analyses are presented in Kellar et al. (1981).

3.5 Nutrient Loading

Total and inorganic nitrogen and phosphorus loads were

determined for the principal inflows to each reservoir and the discharges from each dam. Nutrient concentrations were usually measured monthly in the Colorado River and San Juan River inflows to Lake Powell; the Colorado River, Virgin River, Muddy River and Las Vegas Wash infows to Lake Mead, Hoover Dam, Davis Dam and Parker Dam. Weekly or bi-weekly measurements also were made in Las Vegas Wash during summer (July-September). Discharge data were derived from the U. S. Bureau of Reclamation provisional data for each reservoir.

NUTRIENT

Nutrient loads were computed for each station by equation (1).

$$Q_i = C_i \times V_i \times k_i \ldots . k_n \qquad (1)$$

where:

Q = nutrient loads (kg/month)

C = monthly or average monthly nutrient concentrations (mg/1)

V = average discharge rate (m^3/sec)

k = unit conversion factors

i = time interval (months)

Average annual flow weighted concentrations ($\overline{C}$) were determined by equation (2).

$$\overline{C} = \Sigma \frac{Q_i}{V_i} \times k_i \ldots . k_n \qquad (2)$$

Annual nutrient loads were then computed by multiplying $\overline{C}$

by annual discharge rates.

Evans and Paulson (1983) have shown that a large percentage (10-39%) of the total phosphorus in the Colorado River and tributaries is bound to suspended sediments and unavailable for biological uptake. Based on results of that study bio-available phosphorus (BAP) was estimated by equation (3).

$$BAP = [(TP-OP) \times 0.1] + OP \quad (3)$$

where;

BAP = bio-available phosphorus (mg/1)

TP = total phosphorus (mg/1)

OP = orthophosphorus (mg/1)

3.6 Physical Measurements

Temperature, oxygen, pH and conductivity were measured monthly at each station with a Hydrolab Model IIA or Model 8000 Water Quality Analyzer. Weekly or bi-weekly measurements were also made at the lower basin stations in Lake Mead during summer (July-September). Underwater light transmittance was measured with a Li-Cor Model L-192 Underwater Quantum Sensor.

4.0 RESULTS

4.1 Reservoir Hydrology

The combined inflows to Lake Powell from the Colorado

River, Green River and San Juan River averaged about 475,000 acre-feet per month in 1981 (Fig. 4.1). Runoff in 1981 was lower than normal, and there was only a slight peak during spring. Runoff was much higher in 1982 and averaged 942,000 acre-feet per month (Fig. 4.1). A well-defined peak occurred during spring months. Inflows exceeded 2,000,000 acre-feet per month during spring and remained around 750,000 acre-feet per month during the rest of 1982. Discharges from Glen Canyon Dam averaged 639,000 acre-feet per month in 1981. Discharges were highest during the summer and winter months of 1981 (Fig. 4.1). In 1982, discharges from Glen Canyon Dam averaged 735,000 acre-feet per month. The highest discharges occurred during the summer and fall.

inflow

The Colorado River inflow from Grand Canyon to Lake Mead followed a pattern similar to the discharges from Glen Canyon Dam (Fig. 4.2). Tributaries in Grand Canyon contribute relatively minor inflows in comparison to the Colorado River. Grand Canyon inflows to Lake Mead averaged 653,000 acre-feet per month in 1981 and 749,000 acre-feet per month in 1982.

Discharges from Hoover Dam averaged 690,000 acre-feet per month in 1981 and 621,000 acre-feet per month in 1982. The highest discharges occurred during April of both years. Discharges remained high through the summer in 1981, but then decreased abruptly in the fall. Discharges were lower during the summer of 1982.

The discharges at Davis Dam were similar to those at Hoover Dam (Fig. 4.3). During summer months, discharges at Davis Dam

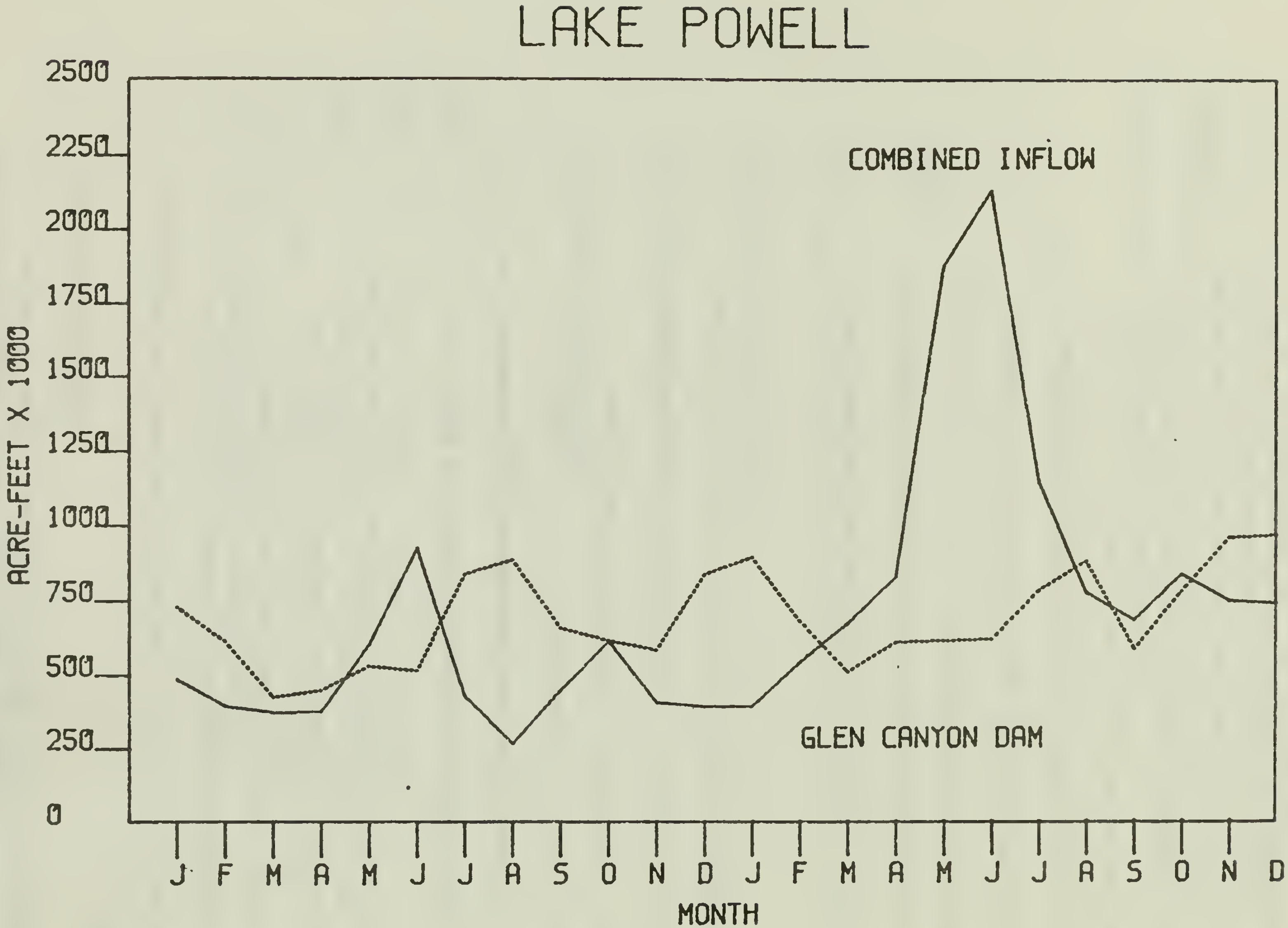

Figure 4.1 Combined inflows (Colorado River and San Juan River) to Lake Powell and discharges from Glen Canyon Dam during January, 1981 through December, 1982 (U.S. Bureau of Reclamation provisional data).

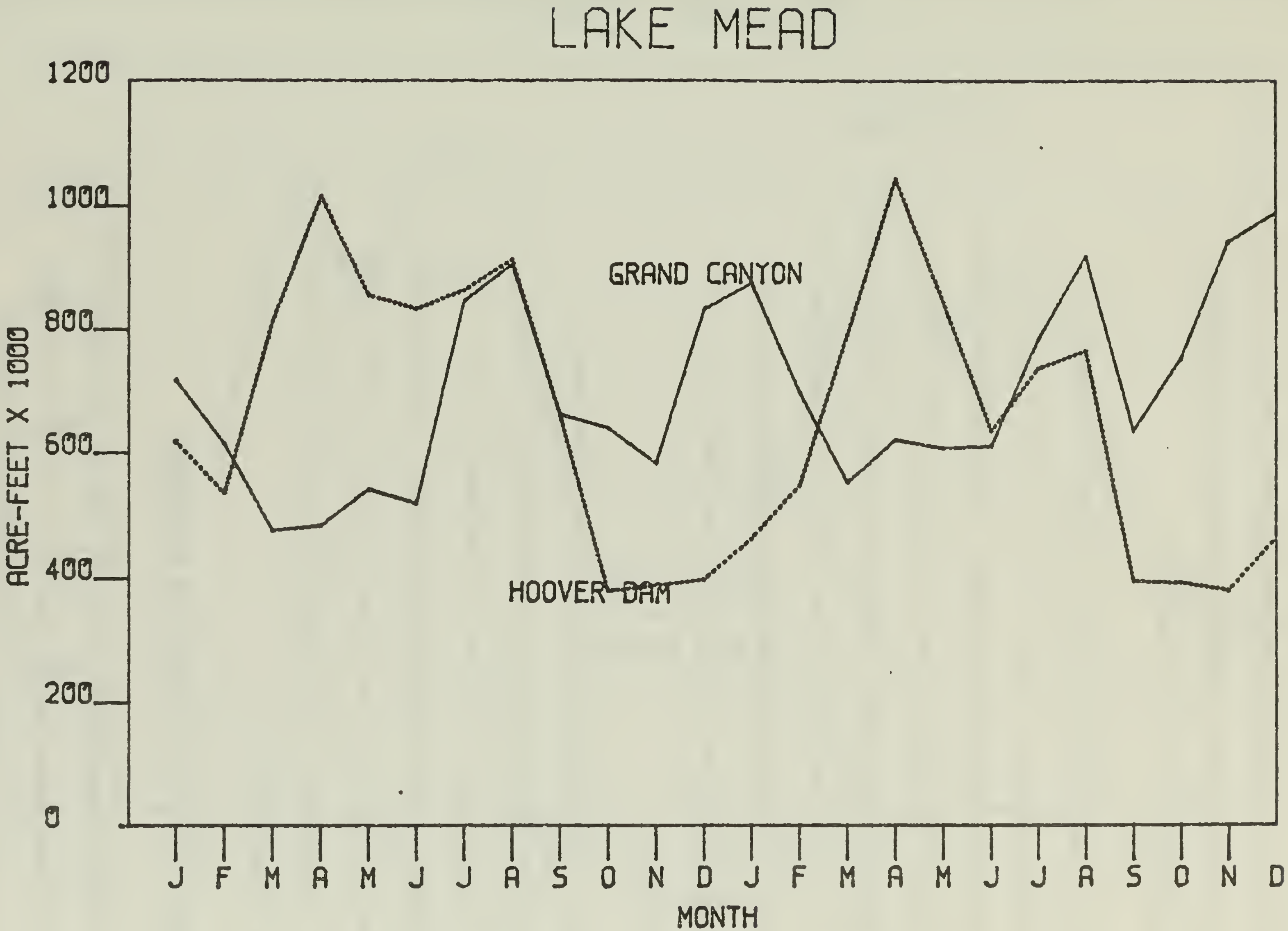

Figure 4.2 Inflows to Lake Mead from Grand Canyon and discharges from Hoover Dam during January, 1981 through December, 1982 (U.S. Bureau of Reclamation provisional data).

were slightly higher than those at Hoover Dam due to draw downs of Lake Mohave. Discharges at Parker Dam followed the same seasonal pattern as Davis Dam (Fig. 4.4). However, the discharges at Parker Dam were consistently lower due to diversions at the California Aqueduct. Diversions were highest during the summer months of both years.

Storage in Lake Powell was nearly constant at about 21.5 million acre-feet during the early months of the study (Fig. 4.5). The volume decreased during summer, fall and winter months of 1981, but than increased during the spring of 1982 (Fig. 4.5). The volume of Lake Powell remained at about 23 million acre-feet during the rest of the study. Storage in Lake Mead did not vary significantly during the study, although volumes were slightly higher during the winter months and lower during the summer (Fig. 4.5).

Storage in Lake Mohave was nearly constant at about 1.7 million acre-feet during the winter and spring of 1981 (Fig. 4.6). The reservoir was drawn down in the summer of 1981, but storage increased again during fall and winter. Storage patterns were similar in 1982, but drawn downs were not as great during the summer. The volume in Lake Havasu did not vary significantly during the study (Fig. 4.6).

4.2 Water Quality of Inflows and Discharges

The average temperatures of the inflows and discharges from the reservoirs are presented in Figure 4.7. The Colorado River inflow to Lake Powell averaged 19.4°C in 1981 and 16.3°C

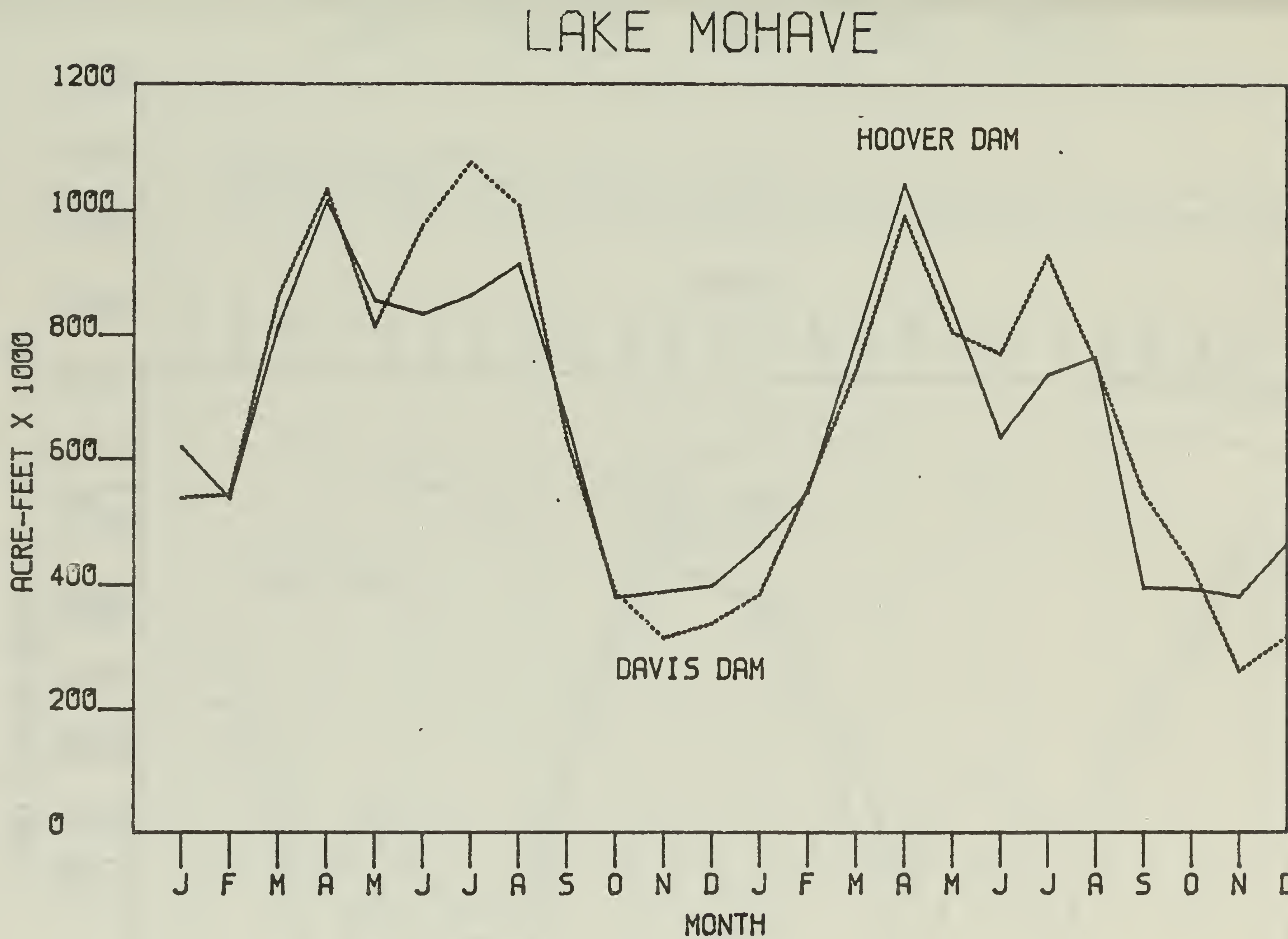

Figure 4.3 Inflows to Lake Mohave from Hoover Dam and discharges from Davis Dam during January, 1981 through December, 1982 (U.S. Bureau of Reclamation provisional data).

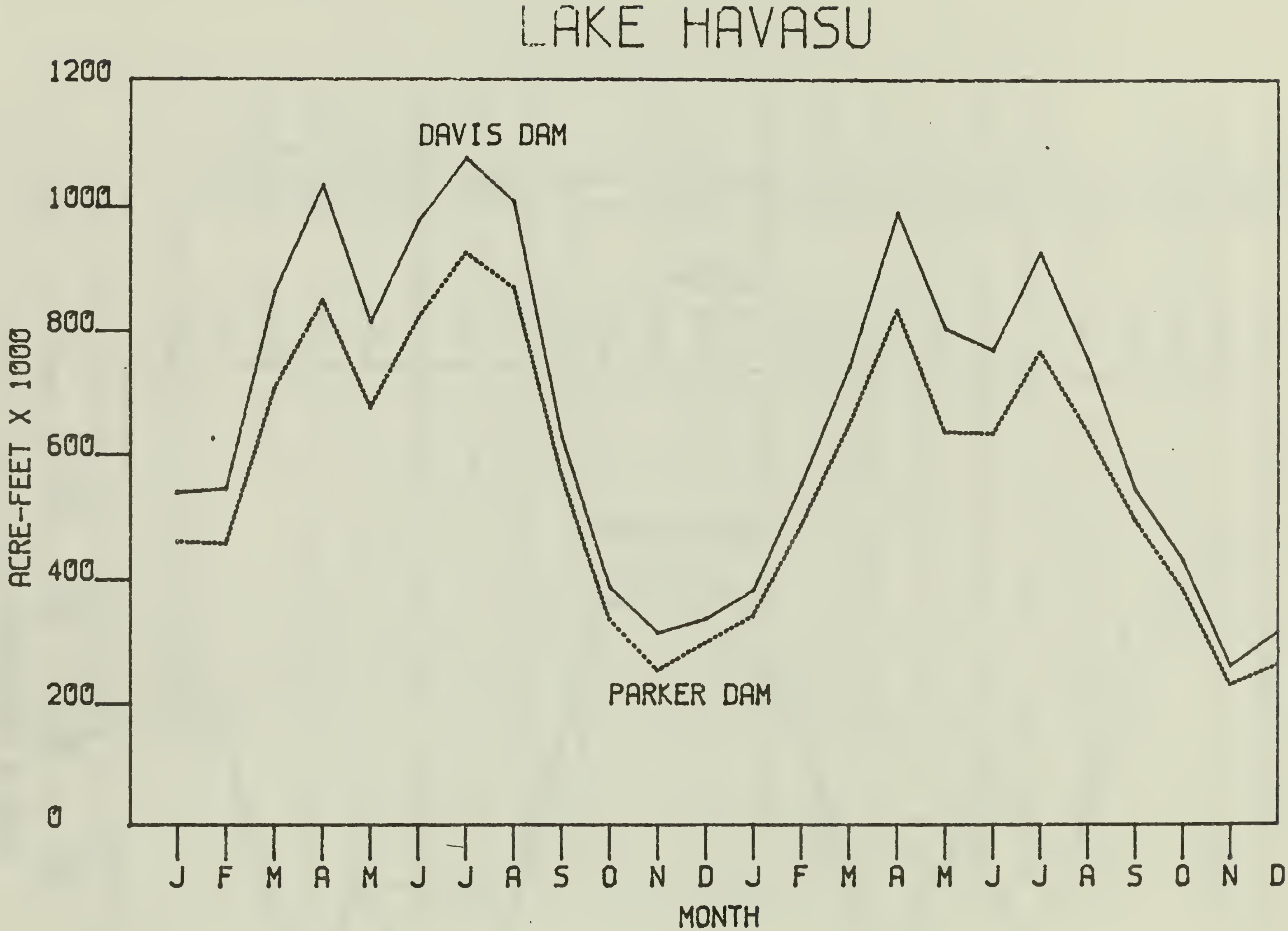

Figure 4.4 Inflows to Lake Havasu from Davis Dam and discharges from Parker Dam during January, 1981 through December, 1982 (U.S. Bureau of Reclamation provisional data).

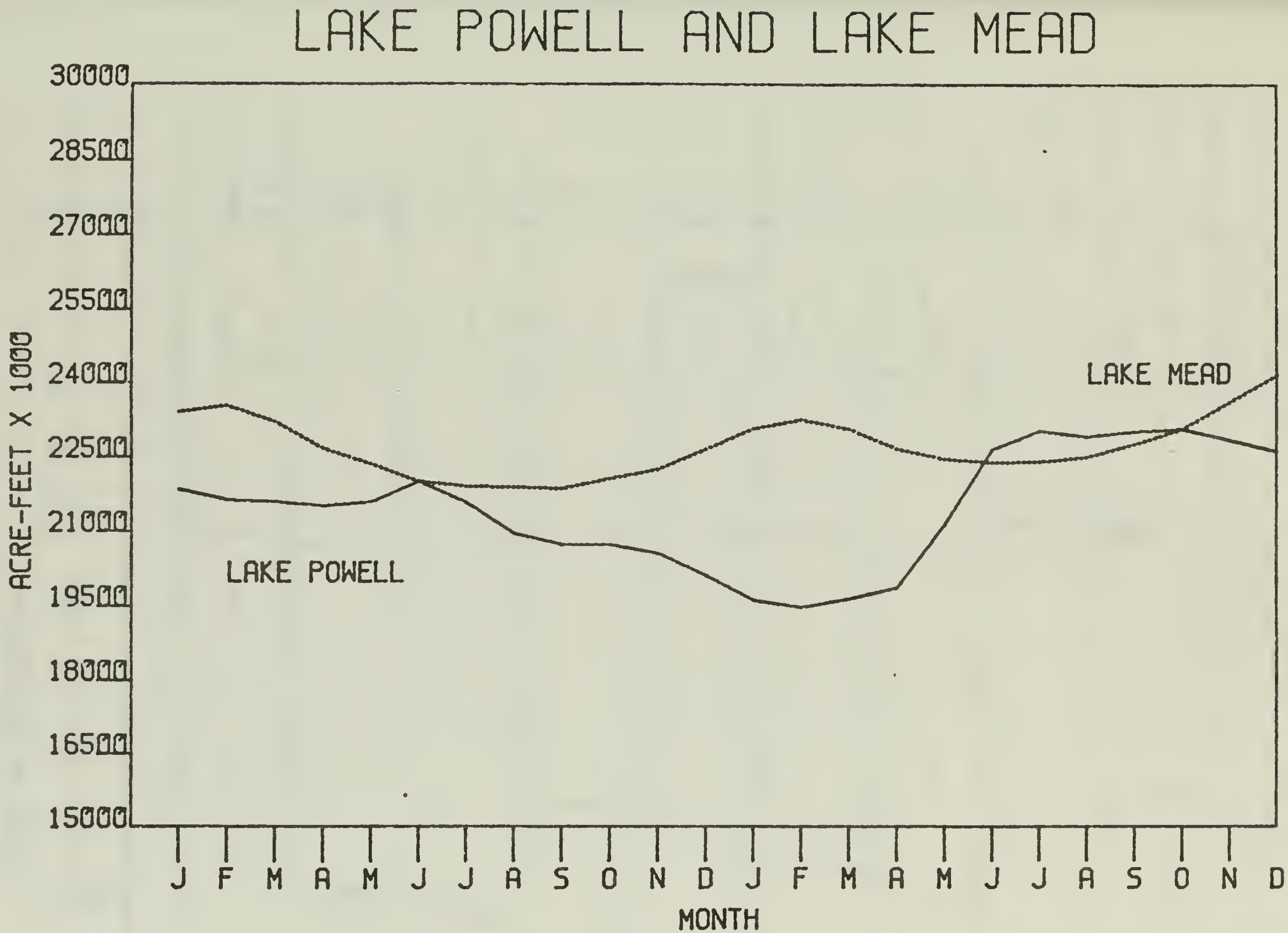

Figure 4.5 Water storage in Lake Powell and Lake Mead during January, 1981 through December, 1932 (U.S. Bureau of Reclamation provisional data).

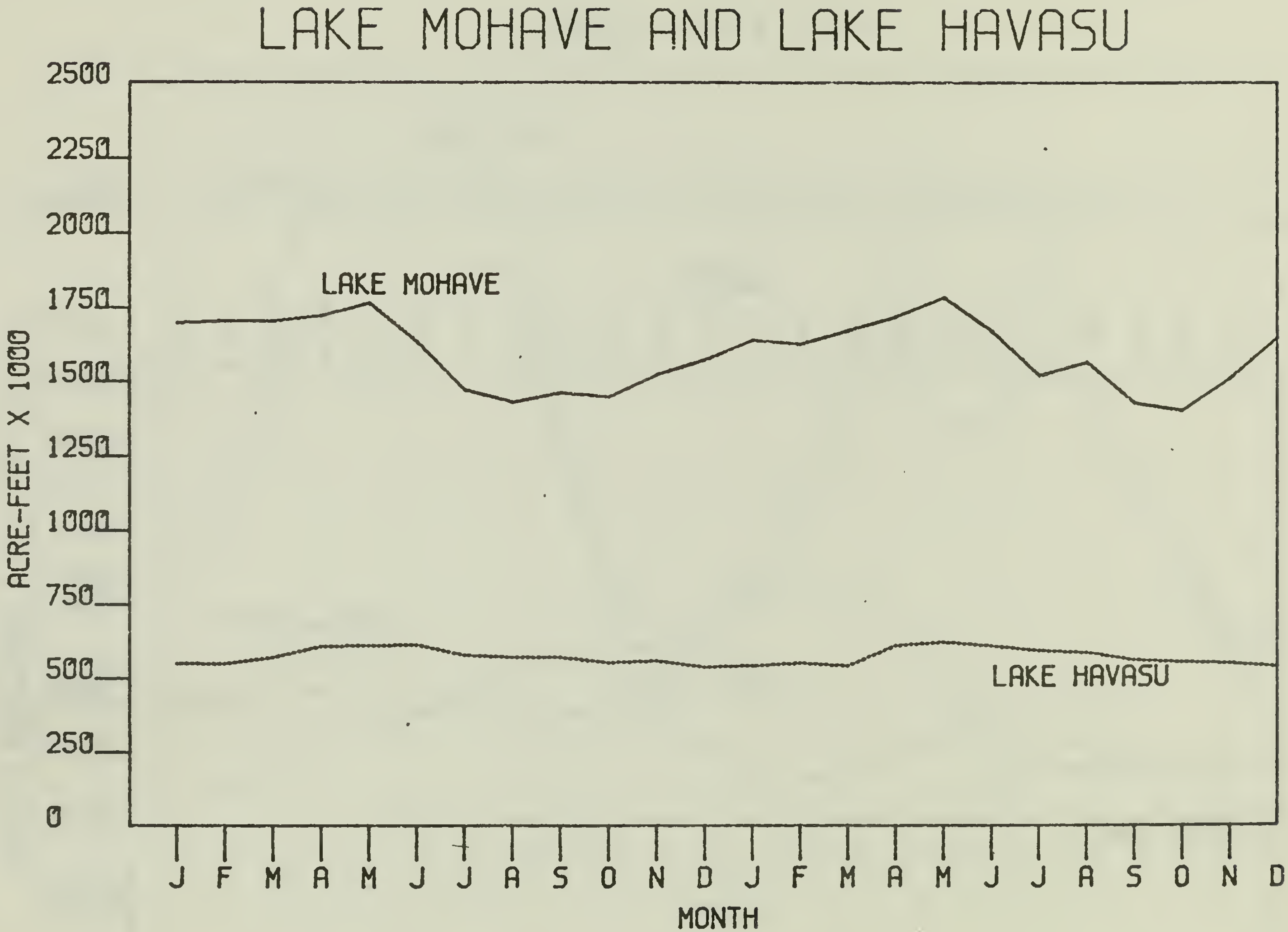

Figure 4.6 Water storage in Lake Mohave and Lake Havasu during January, 1981 through 1982 (U.S. Bureau of Reclamation provisional data).

in 1982 (Fig. 4.7). Temperatures in the San Juan River averaged about 20^{o}C during both years of the study. Discharges from Glen Canyon Dam averaged 10.7^{o}C in 1981 and 9.3^{o}C in 1982 due to withdrawals from the hypolimnion of Lake Powell. Temperatures increased to about 15^{o}C at Grand Canyon (Separation Rapids). Temperatures in discharges from Glen Canyon Dam and at Grand Canyon were slightly colder in 1982 due to higher discharges from Lake Powell.

Temperatures in the Virgin River and Muddy River inflows to Lake Mead averaged about 25^{o}C in 1981 and 22^{o}C in 1982 (Fig. 4.7). Temperatures in Las Vegas Wash were also high and averaged about 20^{o}C during both years of the study. Discharge temperatures at Hoover Dam were nearly constant at 12.5^{o}C (Fig. 4.7). Discharge temperatures averaged about 16^{o}C at Davis Dam and about 20^{o}C at Parker Dam (Fig. 4.7).

The pH of the inflows and discharges for the reservoirs averaged about 7.8 throughout the study (Fig. 4.8).

Dissolved oxygen concentrations in the inflows and discharges are presented in Figure 4.9. Oxygen concentrations averaged about 7-8 mg/l at all the main stem locations, except Grand Canyon. The higher oxygen in Grand Canyon apparently reflects turbulent reaeration that occurs in the rapids. Oxygen concentrations in the tributary inflows were usually higher than the main stem locations (Fig. 4.9). Oxygen concentrations were similar at all locations during 1981 and 1982, except for the San Juan River and the Virgin and Muddy Rivers. The annual

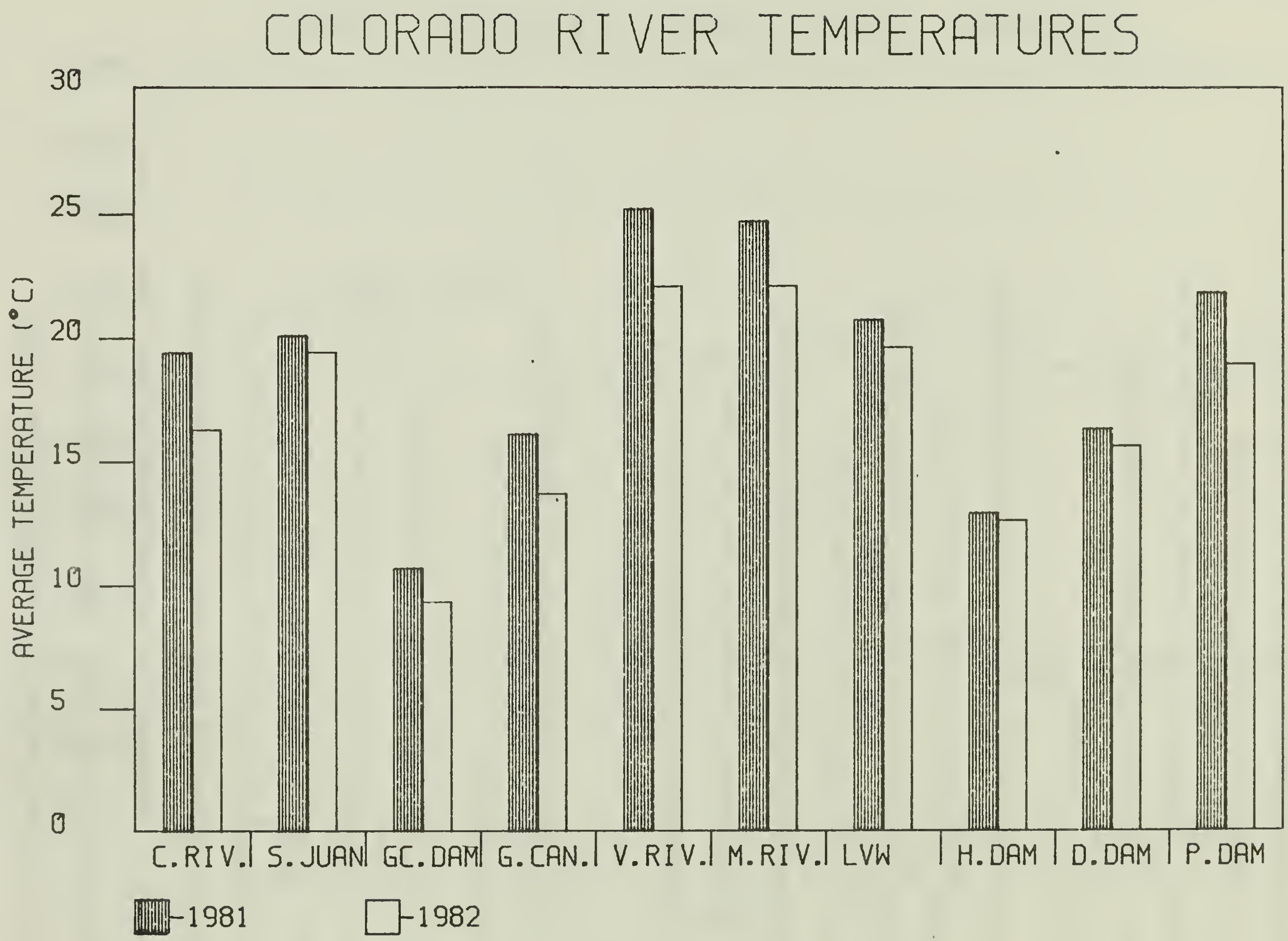

Figure 4.7 Average annual temperatures in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

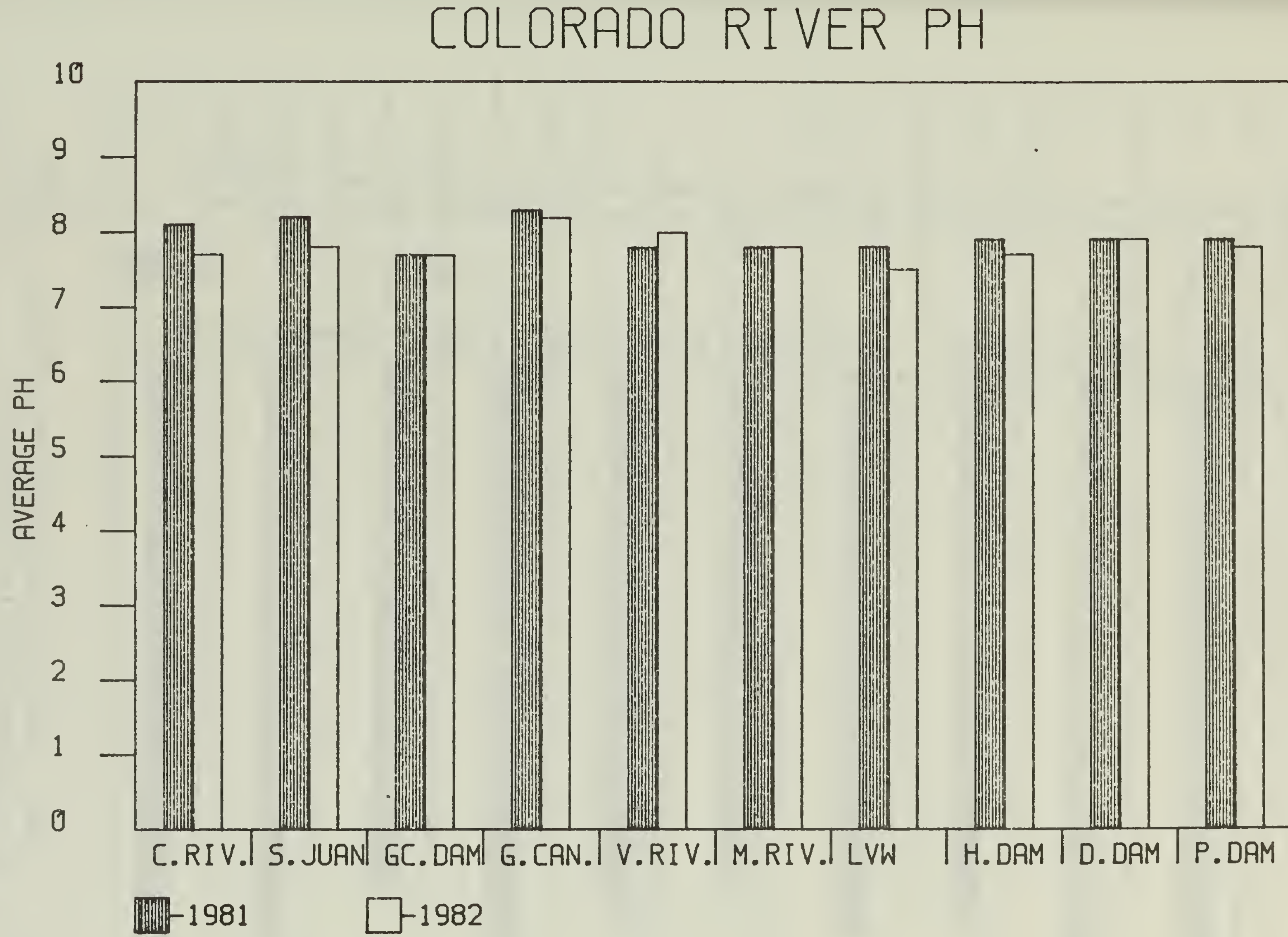

Figure 4.8 Average annual pH in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

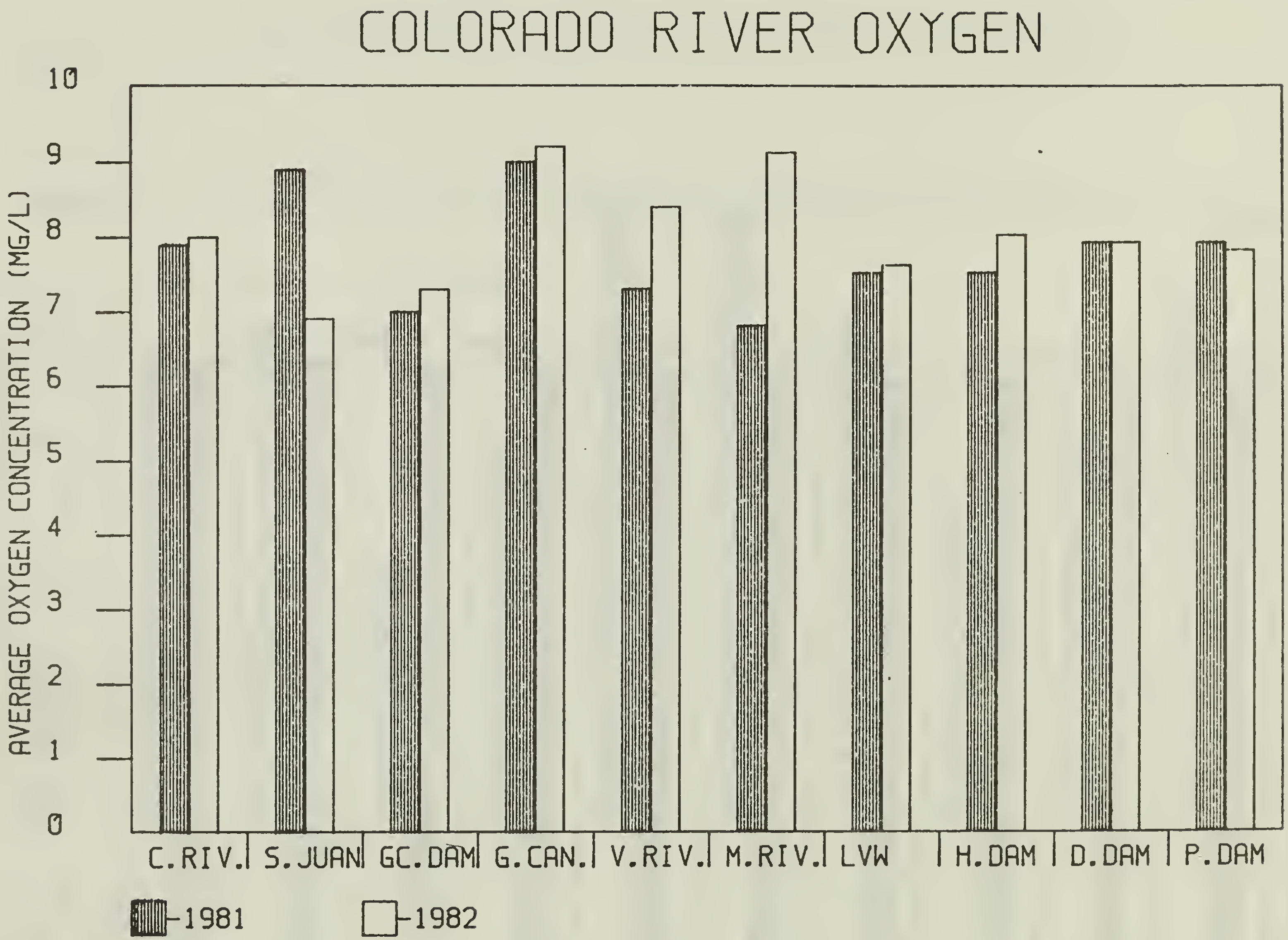

Figure 4.9 Average annual dissolved oxygen in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

differences in oxygen at these stations most likely reflect differences in biological activity in the rivers.

The conductivity in the Colorado River inflow to Lake Powell averaged 1057 μmhos /cm in 1981 and 915 μmhos /cm in 1982 (Fig. 4.10). Conductivity was slightly lower in the San Juan River and at Glen Canyon Dam during 1982. The Virgin and Muddy Rivers and Las Vegas Wash were quite saline and conductivities averaged about 2700 μmhos /cm at these stations during both years of the study. The conductivity of discharges from Hoover Dam averaged about 1100 μmhos /cm during 1981 and 1982 (Fig. 4.10). There was only a slight increase in conductivity between Hoover Dam and Parker Dam (Fig. 4.10).

4.3 Temperature Structure in the Reservoirs

The temperature structure at select stations in Lake Powell are shown in Figures 4.11 - 4.14. Temperatures throughout the reservoir were isothermal at about 10°C during the winter months. The reservoir began warming in April and May, and thermal stratification was well developed by June. Surface temperatures reached their maximum in August and September and ranged to 26-28°C (Figs. 4.11 - 4.14). In 1981, the thermocline was located at 15-16 m at Hite (1a) and Hall's Crossing (3) and at 12-15 m at Rainbow (3c) and Wahweap (5) (Figs. 4.11 - 4.14). The reservoir began to destratify in October and was mixed by January.

Thermal stratification was somewhat different in Lake Powell in 1982. Thermal stratification was more diffuse than in

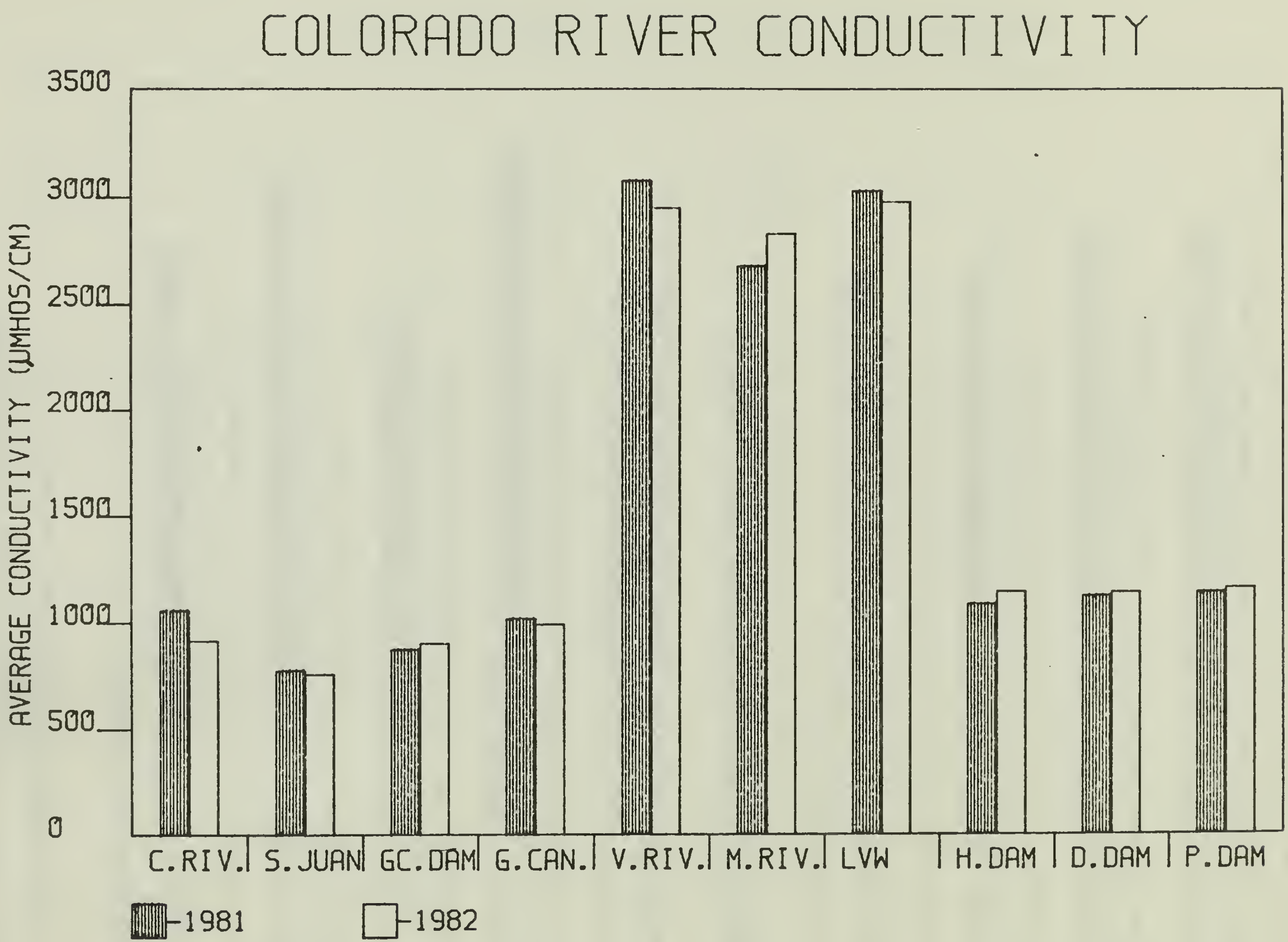

Figure 4.10 Average annual conductivity in main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

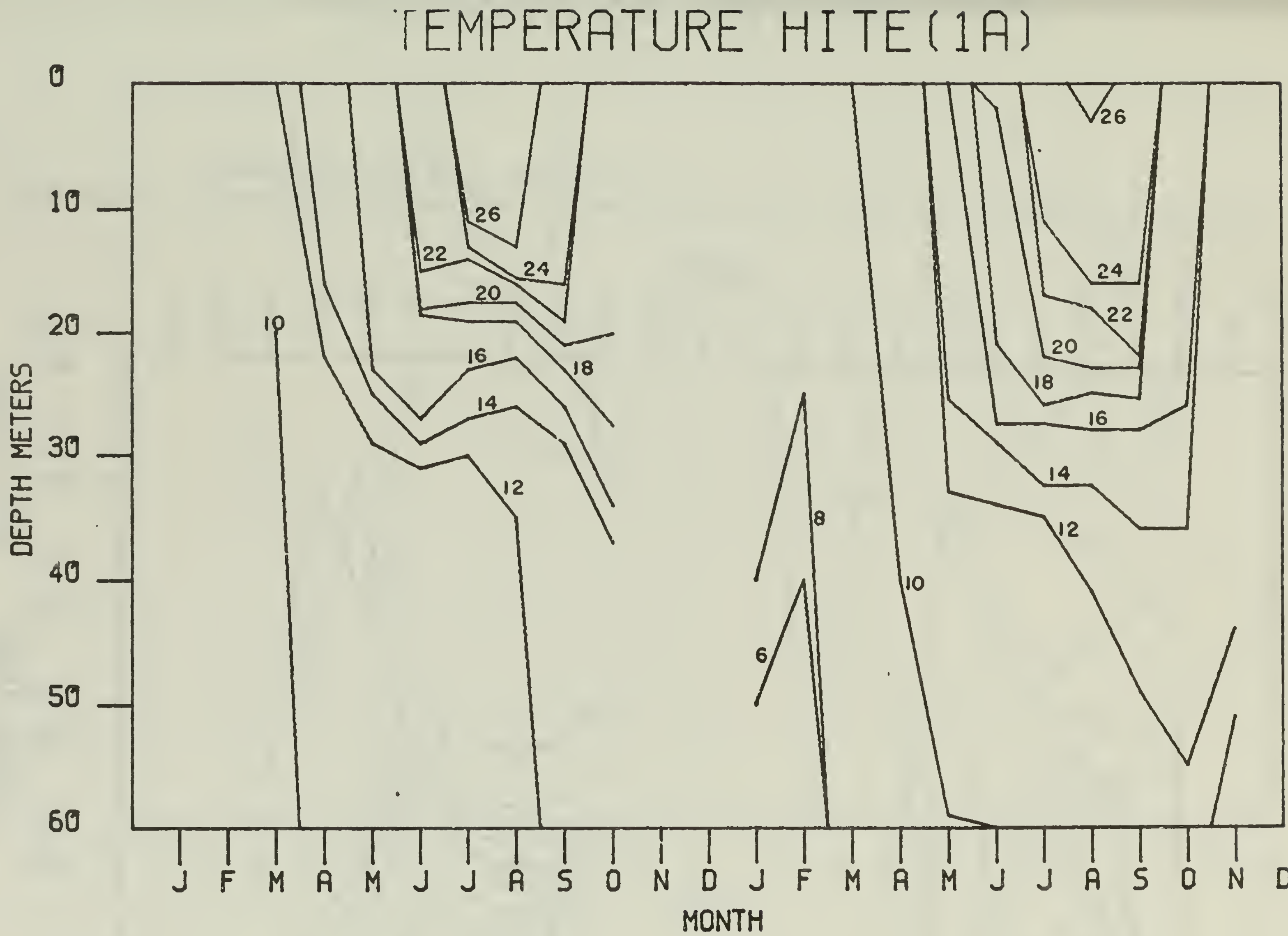

Figure 4.11 Temperature isotherms from upper 60m at Hite (la) in Lake Powell during 1981 and 1982.

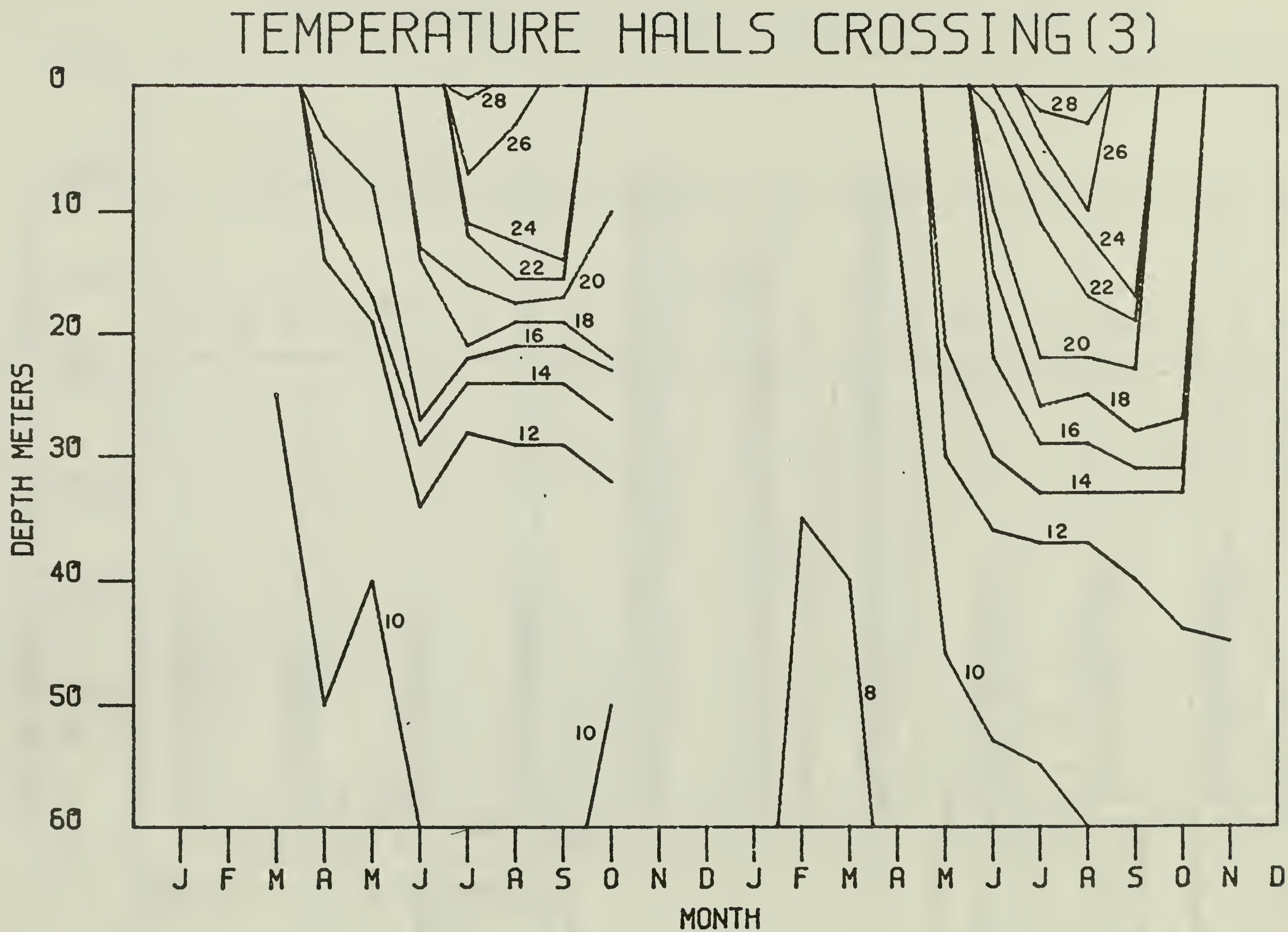

Figure 4.12 Temperature isotherms from upper 60m at Halls Crossing (3) in Lake Powell during 1981 and 1982.

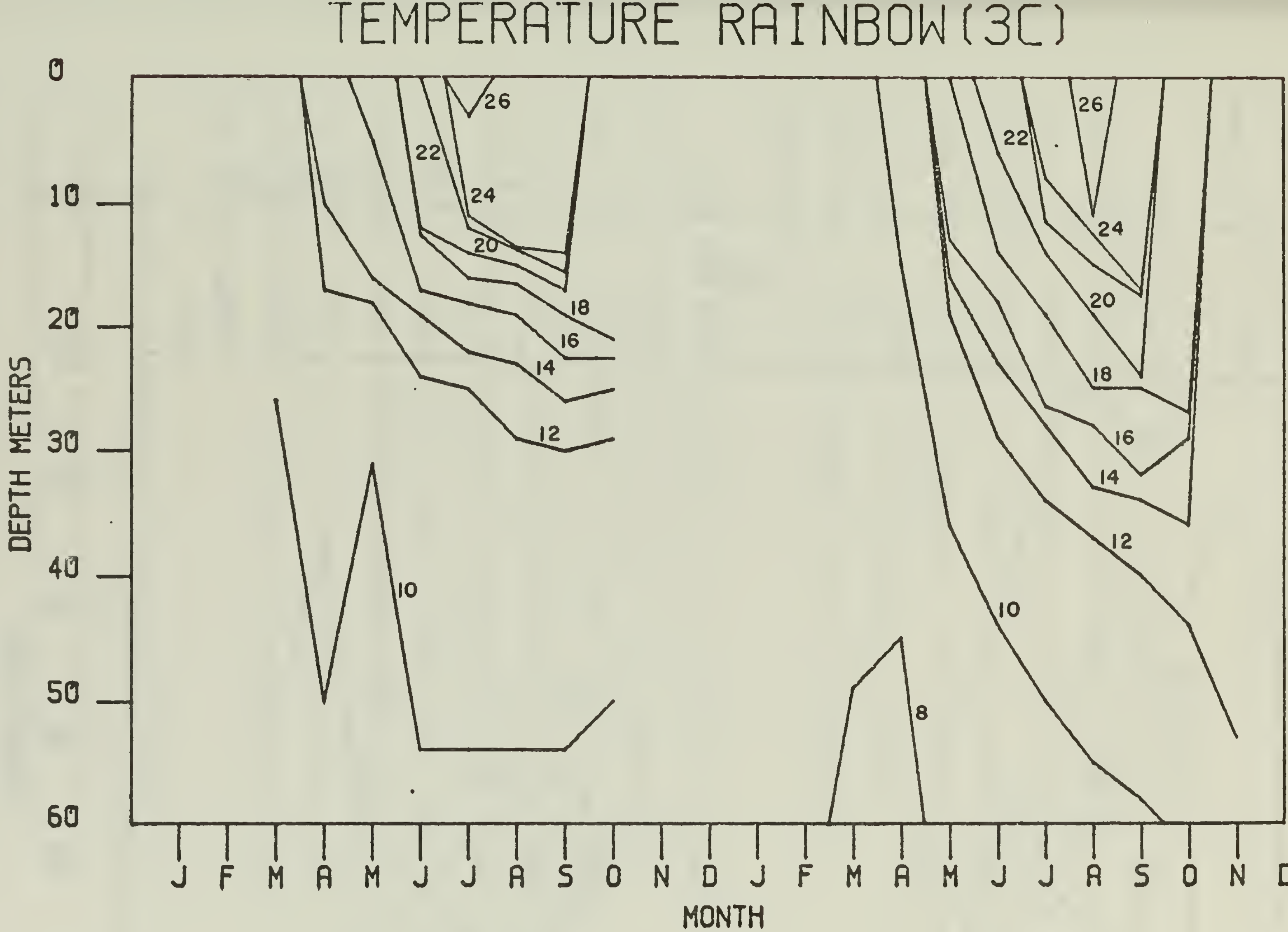

Figure 4.13 Temperature isotherms from upper 60m at Rainbow Marina (3c) in Lake Powell during 1981 and 1982.

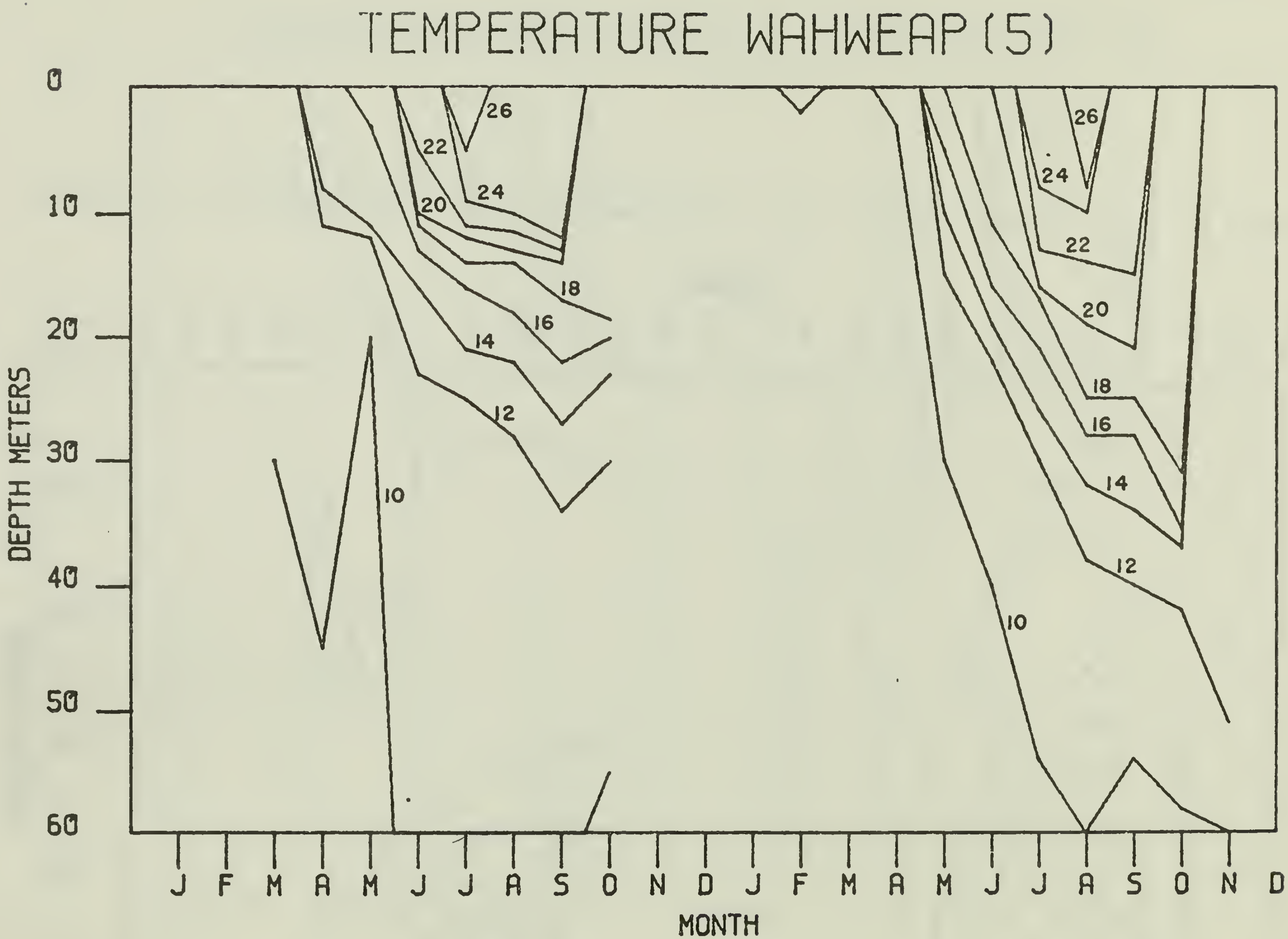

Figure 4.14 Temperature isotherms from upper 60m at Wahweap (5) in Lake Powell during 1981 and 1982.

1981. The thermocline was generally deeper throughout the reservoir. Surface temperatures were similar to those in 1981, as were hypolimnion temperatures. Destratification occurred in October, 1982, and the reservoir was nearly completely mixed by November.

Water temperatures in the four major basins of Lake Mead were isothermal at 11-12°C from December through February (Figs. 4.15 - 4.18). Surface temperatures began to increase in March and by June a distinct thermocline had developed. The thermocline was located at approximately 10 m during June and declined to a depth of 15-18 m by September as surface temperatures cooled. By December, the lake was generally completely mixed.

There were some differences in thermal structure between the major basins with Gregg and Temple Basins being similar (Figs. 4.15 - 4.16) and Virgin and Boulder Basins being similar (Figs. 4.17 -4.18). Maximum water temperatures in Gregg and Temple Basins were approximately 2°C warmer than those found in Virgin and Boulder Basins. Gregg and Temple Basins also had cooler hypolimnetic temperatures resulting in stronger thermal stratificiation. The cooler hypolimnetic temperatures in those basins were the result of cold-water inflows from the Colorado River during summer.

There were some differences in the thermal structure in Lake Mead between 1981 and 1982 at all stations. Spring temperatures (April-May) were generally 1-2°C warmer in 1981. However, late summer temperatures (August-September) were

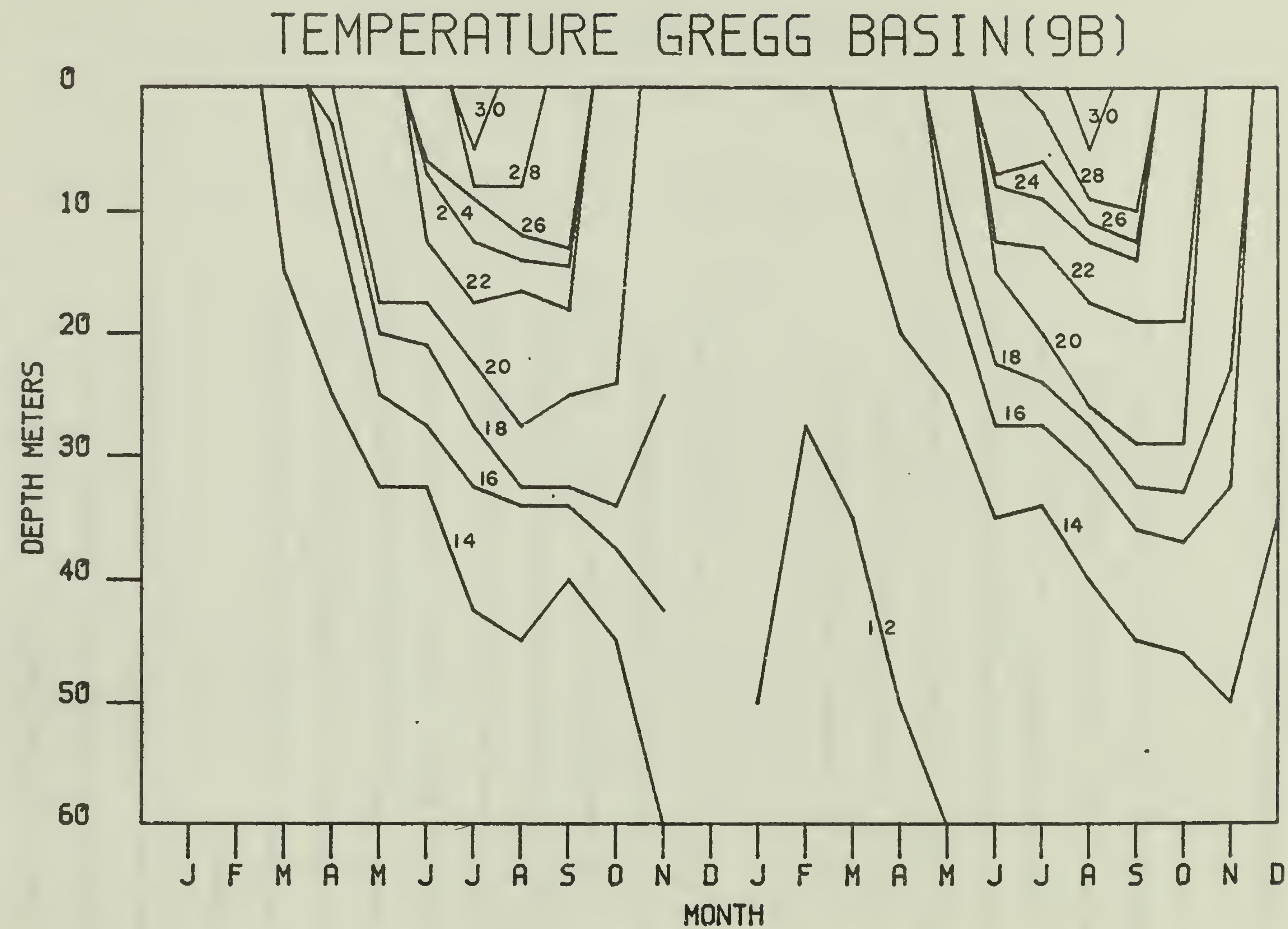

Figure 4.15 Temperature isotherms from upper 60m at Gregg Basin (9b) in Lake Mead during 1931 and 1982.

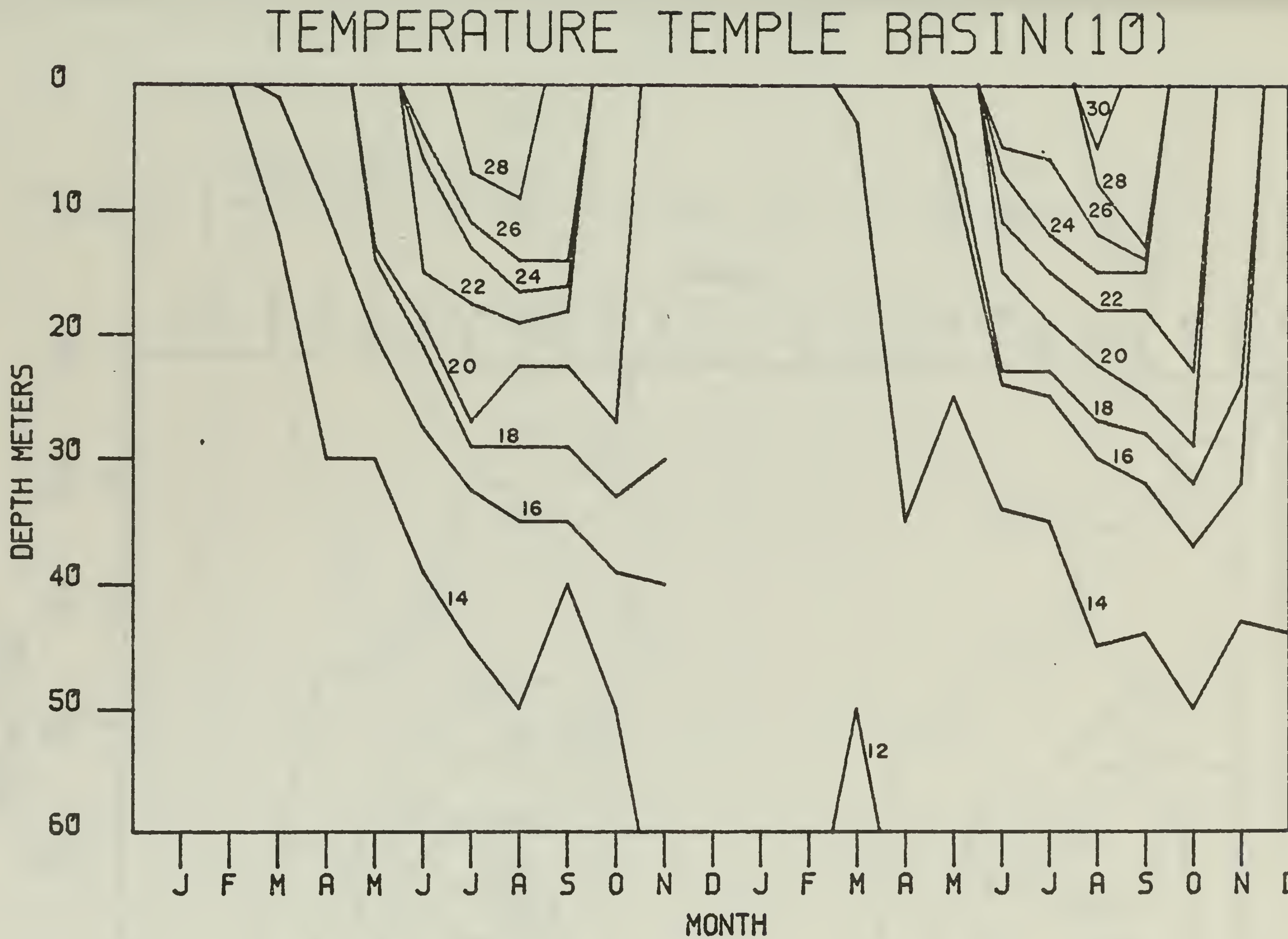

Figure 4.16 Temperature isotherms from upper 60m at Temple Basin (10) in Lake Mead during 1981 and 1982.

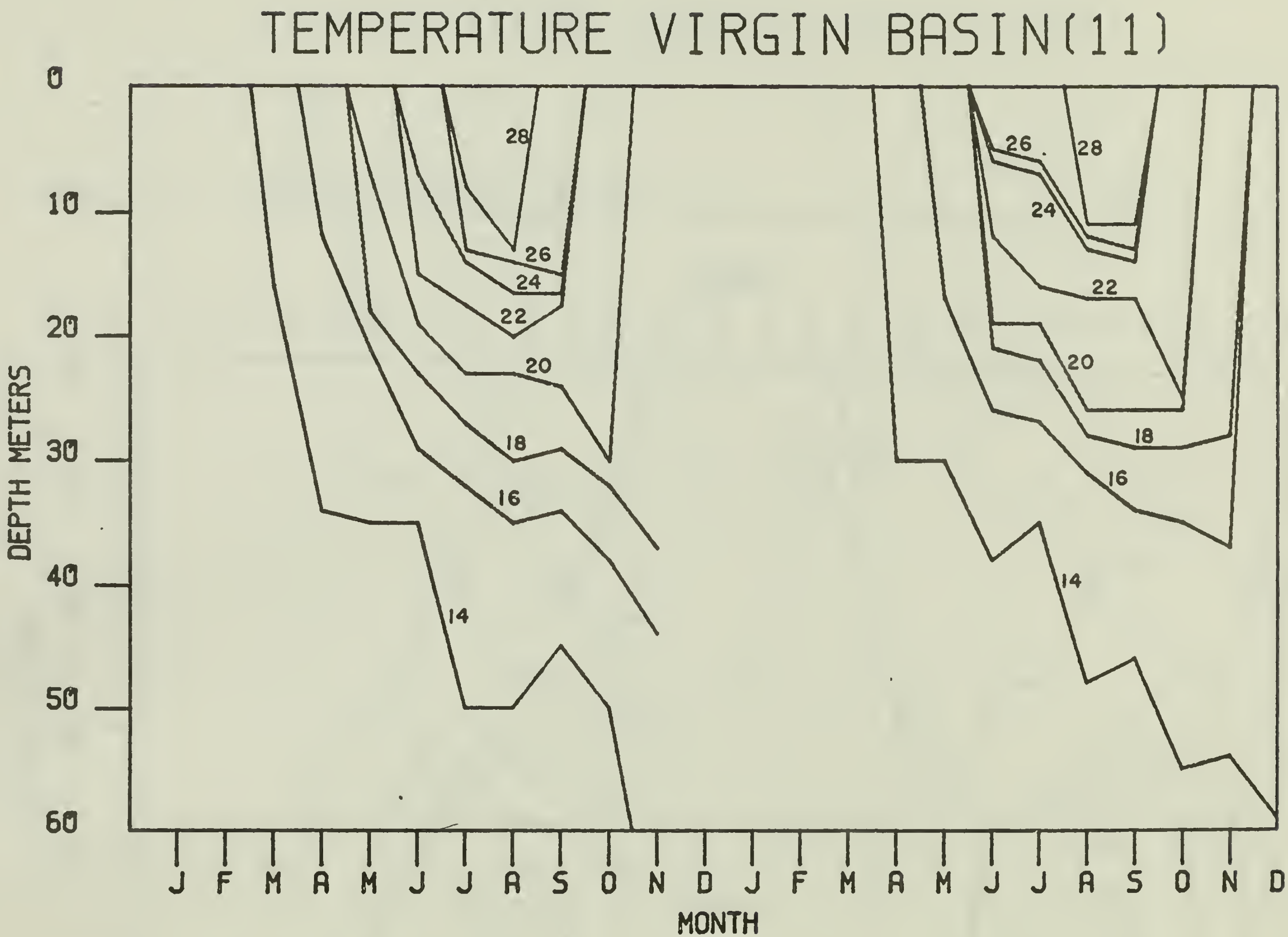

Figure 4.17 Temperature isotherms from upper 60m at Virgin Basin (11) in Lake Mead during 1981 and 1982.

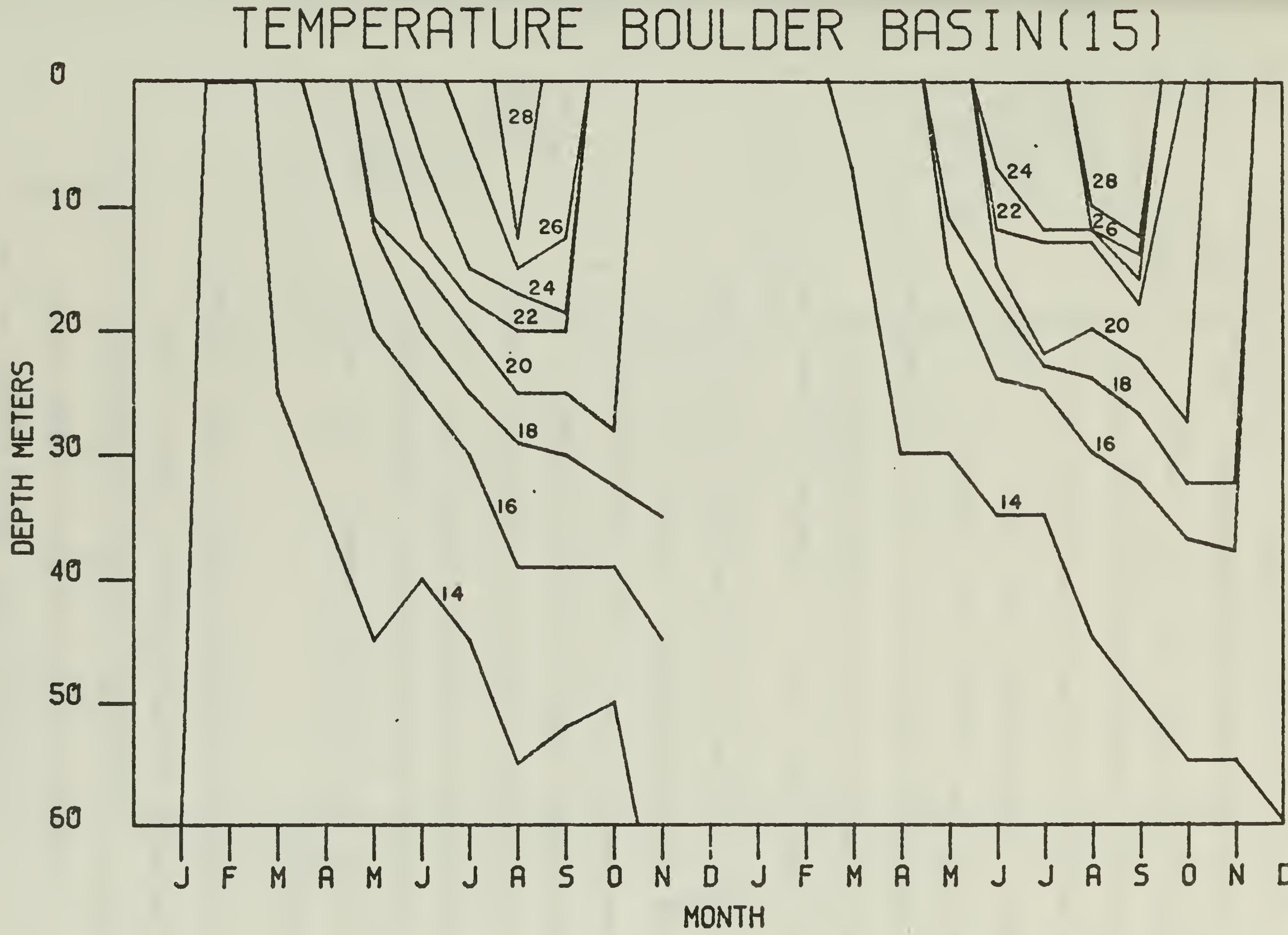

Figure 4.18 Temperature isotherms from upper 60m at Boulder Basin (15) in Lake Mead during 1981 and 1932.

generally 2°C warmer in 1982. Thermal stratification was stronger, and a shallower thermocline existed with the warm, late-summer temperatures in 1982.

Temperatures in Lake Mohave were isothermal at 10-12°C during the winter months (Figs. 4.19 - 4.21). Thermal stratification began to develop in April and May, and the reservoir was stratified by June. Thermal stratification was extremely sharp at Eldorado Canyon (17b) (Fig. 4.19). Surface temperatures ranged from 28-30°C at this station. The thermocline was usually located at 6-8 m, and it was common to have a thermal gradient of 2-3°C per meter. This was due to the underflow of cold water from the discharges at Hoover Dam.

Thermal stratification at Cottonwood Basin (18) was also affected by the underflow from Hoover Dam (Fig. 4.20). The thermocline was located at about 10-12 m, and the thermal gradient was very sharp, especially during the summer of 1981 (Fig. 4.20). The temperature structure at Katherine's Landing (19) was different than the upstream stations (Fig. 4.21). Thermal stratification did not develop until late July and August in 1981 and also was delayed somewhat in 1982, compared to upstream stations.

Thermal stratification did not develop in upper or middle Lake Havasu because of the shallow depths. However, it did develop at Parker Dam (24) where the depth was about 24 m. Temperatures in Lake Havasu were about 10-12°C during winter months (Fig. 4.22). The reservoir began warming in April and May and was stratified by June. Surface temperatures ranged to

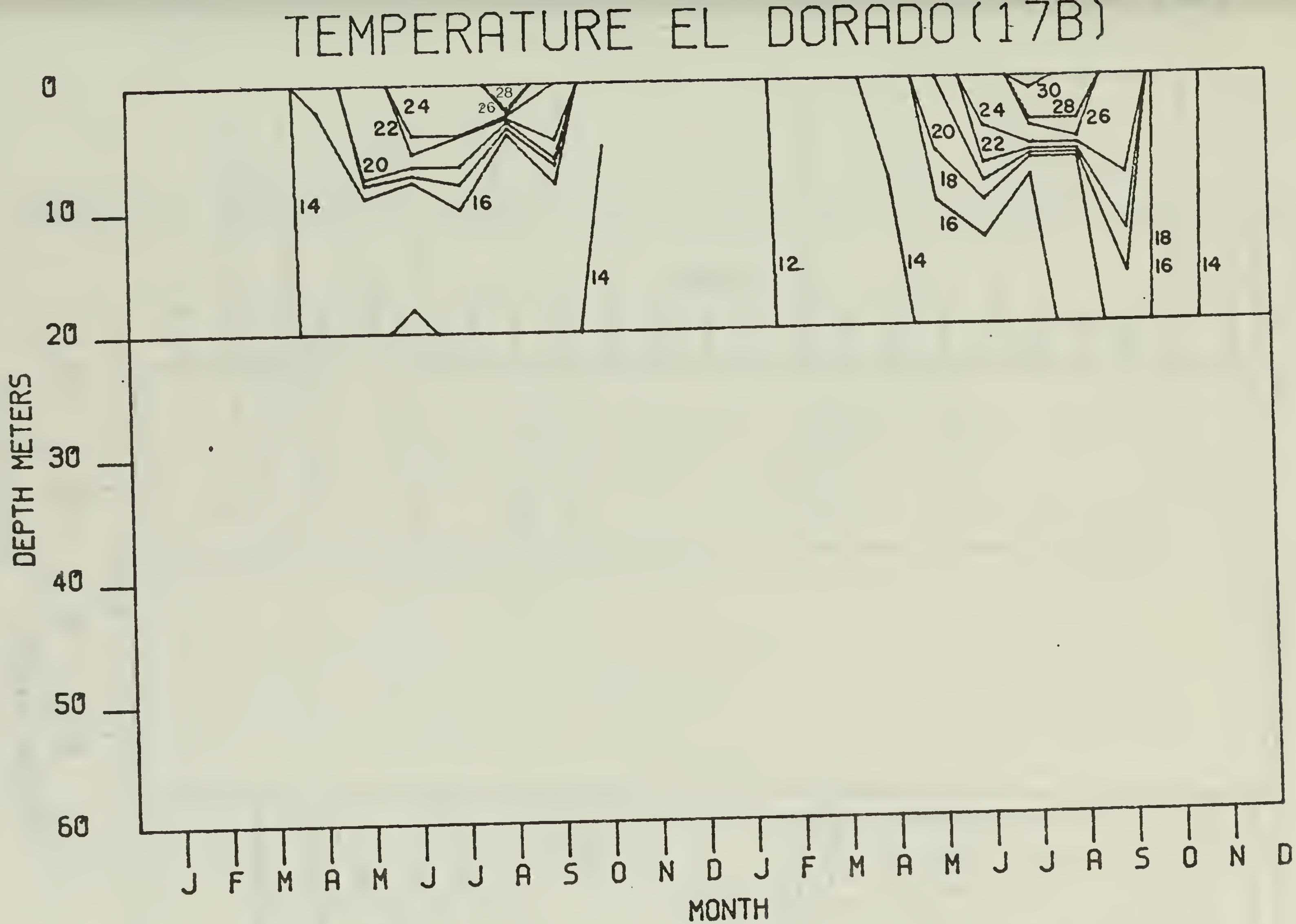

Figure 4.19 Temperature isotherms from Eldorado Canyon (17b) in Lake Mohave during 1981 and 1982.

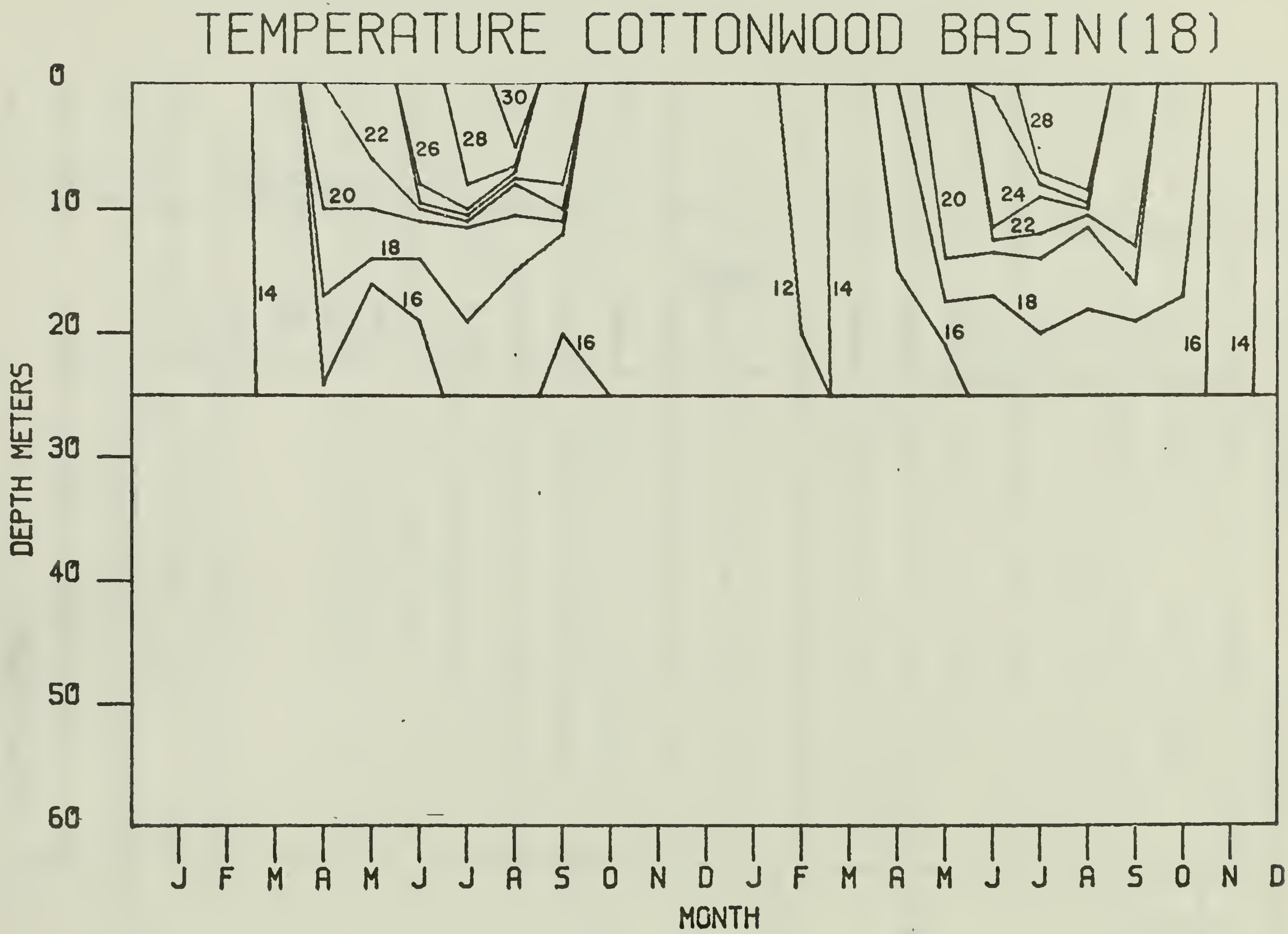

Figure 4.20 Temperature isotherms from Cottonwood Basin (18) in Lake Mohave during 1981 and 1982.

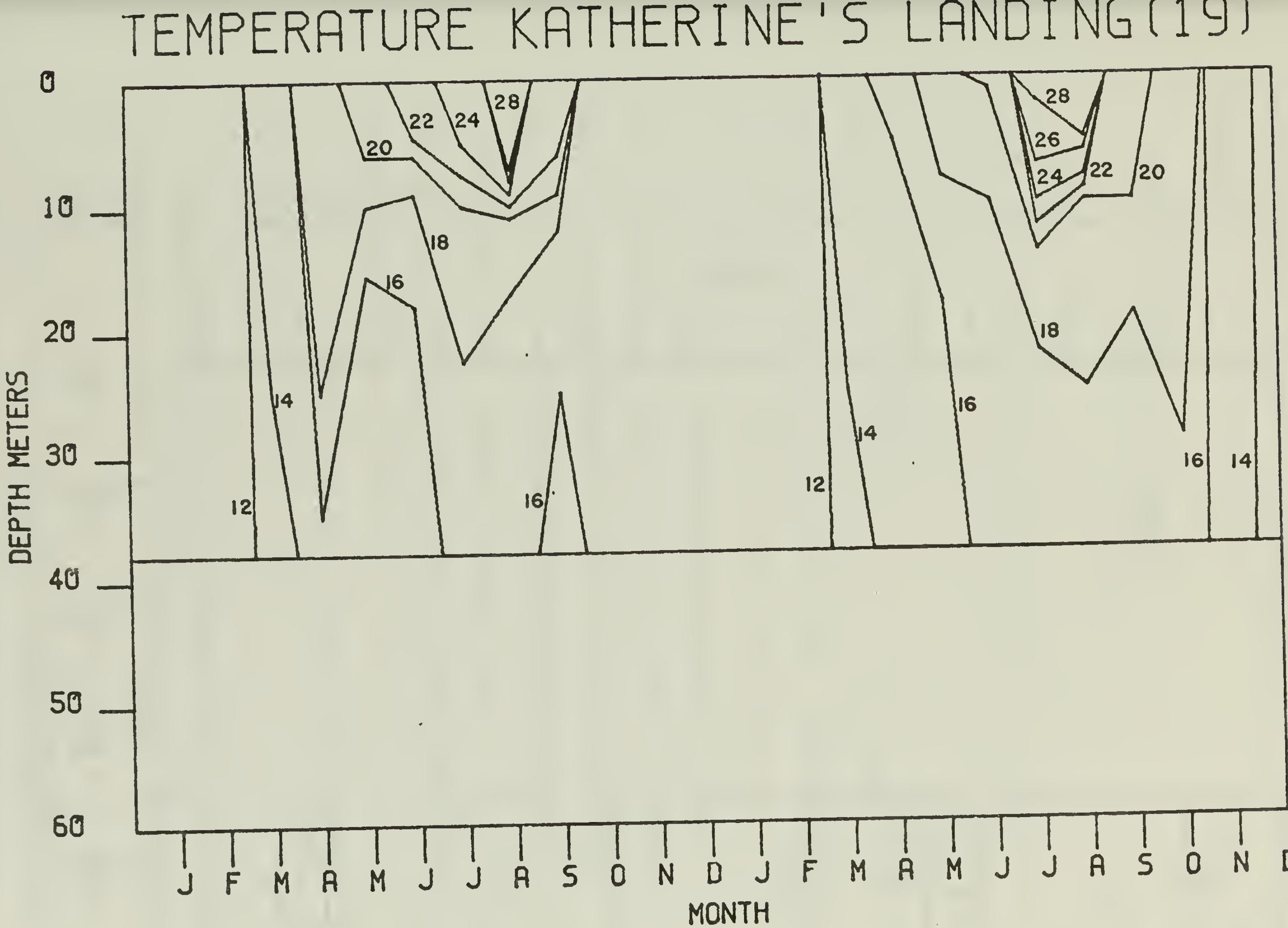

Figure 4.21 Temperature isotherms from Katherine's Landing (19) in Lake Mohave during 1981 and 1982.

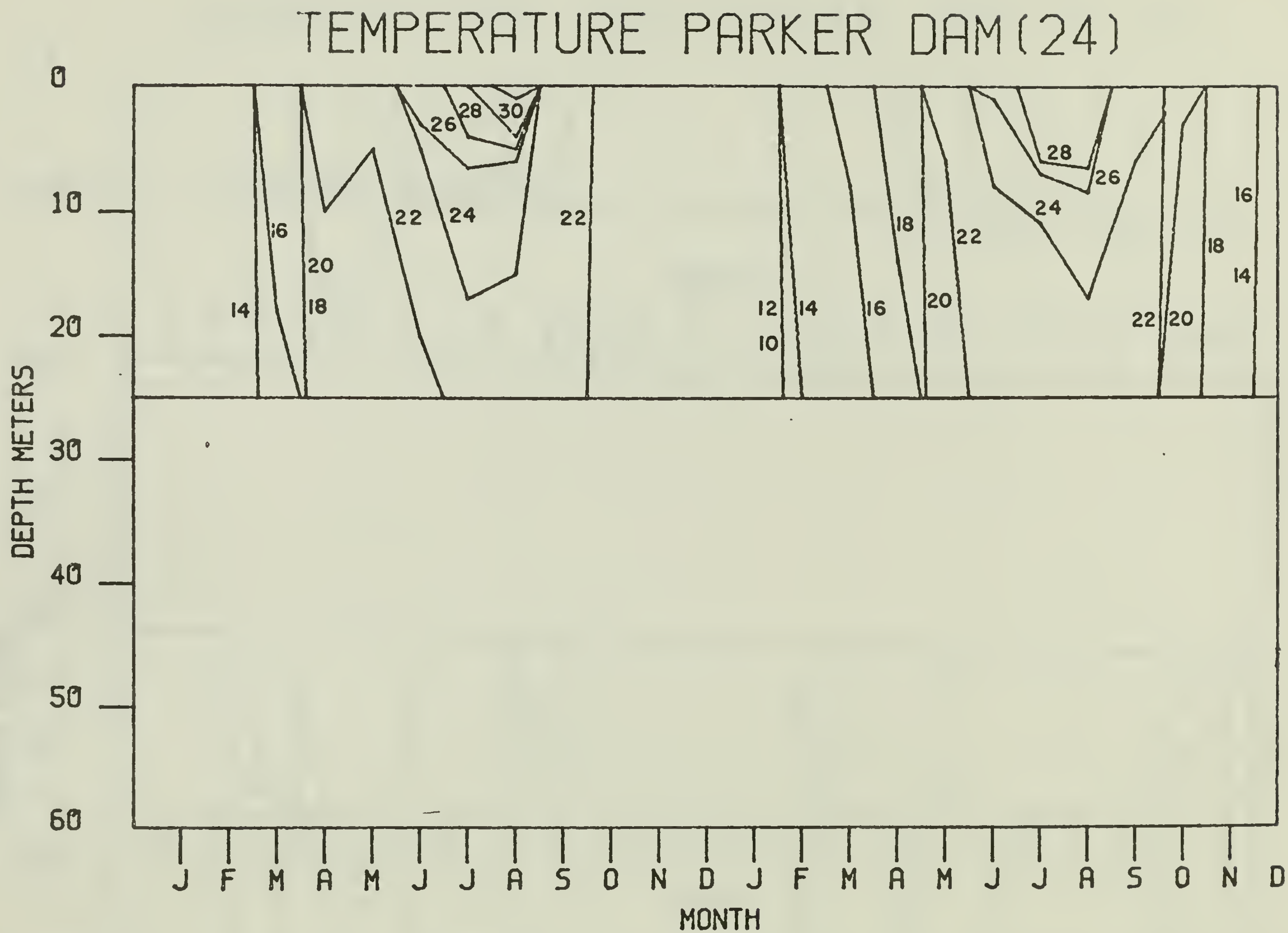

Figure 4.22 Temperature isotherms above Parker Dam (24) in Lake Havasu during 1981 and 1982.

$32^{o}C$ at the dam in 1981 and $28^{o}C$ in 1982. Although a thermocline developed at about 10 m, temperatures were relatively warm (22-24^{o}C) all the way to the bottom. The reservoir began to destratify in September and was nearly mixed by November.

4.4 Nutrient Loading and Budgets

Inorganic nitrogen (primarily nitrate) loads in the Colorado River inflow to Lake Powell totaled about 2300 t/yr. in 1981 (Fig. 4.23). This increased to nearly 5000 t/yr. in 1982 due to the higher spring runoff. The San Juan River was also a significant source of inorganic nitrogen to Lake Powell, but loads were much lower than the Colorado River. Inorganic nitrogen loads at Glen Canyon Dam were about 3400 t/yr. in 1981 and 4400 t/yr. in 1982. Inorganic nitrogen loads increased slightly between Glen Canyon Dam and Grand Canyon (Separation Rapids) in 1981, but decreased in 1982. The Virgin and Muddy Rivers were relatively minor sources of inorganic nitrogen to Lake Mead (Fig. 4.23). Inorganic nitrogen loads in Las Vegas Wash were about 800 t/yr. during 1981 and 1982. Inorganic nitrogen loads at Hoover Dam were about 3500 t/yr. in 1981 and about 2900 t/yr. in 1982. Inorganic nitrogen loads decreased downstream from Hoover Dam (Fig. 4.23).

The spatial patterns in total nitrogen loads in the inflows and discharges were similar to those for inorganic nitrogen (Fig. 4.24). Total nitrogen loads in the Colorado River inflow to Lake Powell were high, particularly in 1982. Total nitrogen loads were about 6000 t/yr at Glen Canyon Dam and increased

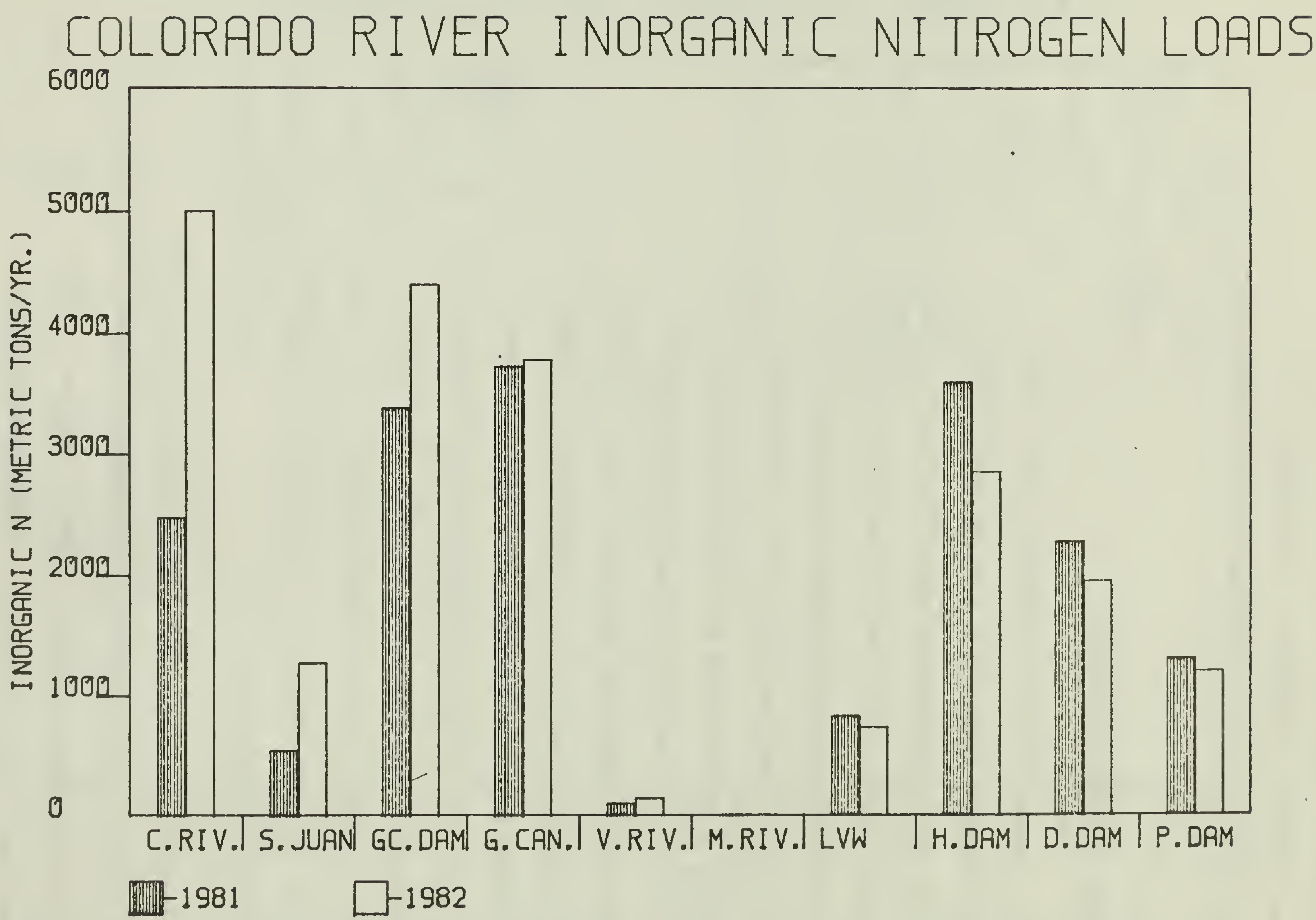

Figure 4.23 Inorganic (NO_3+NO_2+NH_3) nitrogen loads in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

slightly in Grand Canyon. Total nitrogen loads decreased at the main stem locations downstream from Grand Canyon. The Virgin and Muddy Rivers inflows to Lake Mead were a minimal source of total nitrogen. Las Vegas Wash contributed about 800-900 t/yr. of total nitrogen to Lake Mead (Fig. 4.24).

Total phosphorus loads in the Colorado River inflow to Lake Powell were extremely high (Fig. 4.25). These totaled 3890 t/yr. in 1981 and 6402 t/yr. in 1982. The higher loading in 1982 was primarily due to greater inflows during the spring. Total phosphorus loads in the San Juan River were also high during 1982. This was largely due to extremely high total phosphorus concentrations in the river during the summer months following flash floods.

Total phosphorus loads decreased considerably in Lake Powell and totaled about 70 t/yr. at Glen Canyon Dam during 1981 and 1982. Total phosphorus loads increased between Glen Canyon Dam and Grand Canyon due primarily to inputs from the Little Colorado River and other tributaries in the canyon. The Virgin River was a significant source of total phosphorus to Lake Mead (Fig. 4.25).

Total phosphorus loads decreased to about 100 t/yr. at Hoover Dam and Davis Dam. Total phosphorus loads at Parker Dam were slightly higher than at Davis Dam apparently due to inputs from the Bill Williams River.

A large percentage of the total phosphorus in the Colorado River is bound to suspend sediments and unavailable to

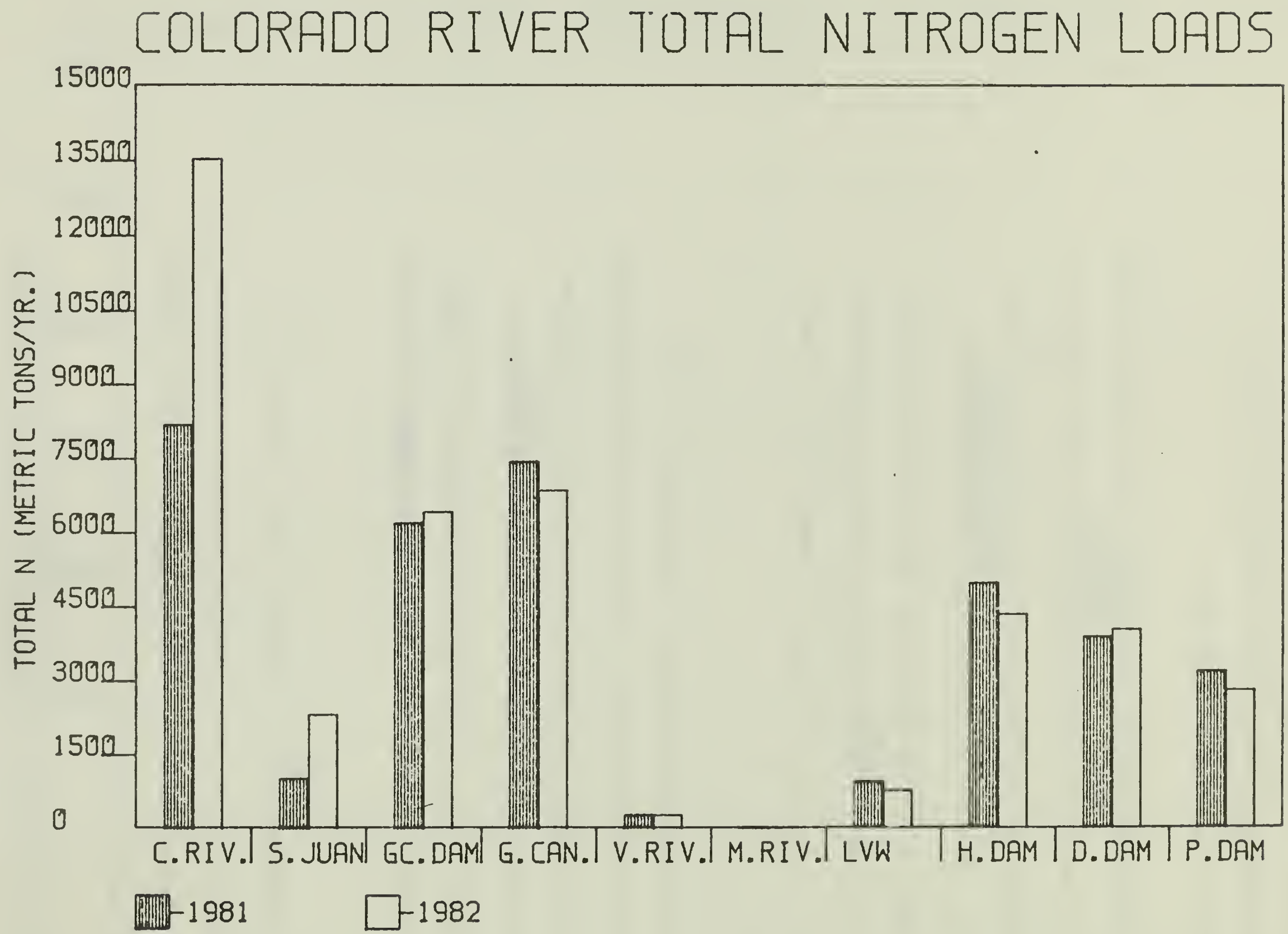

Figure 4.24 Total nitrogen loads in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

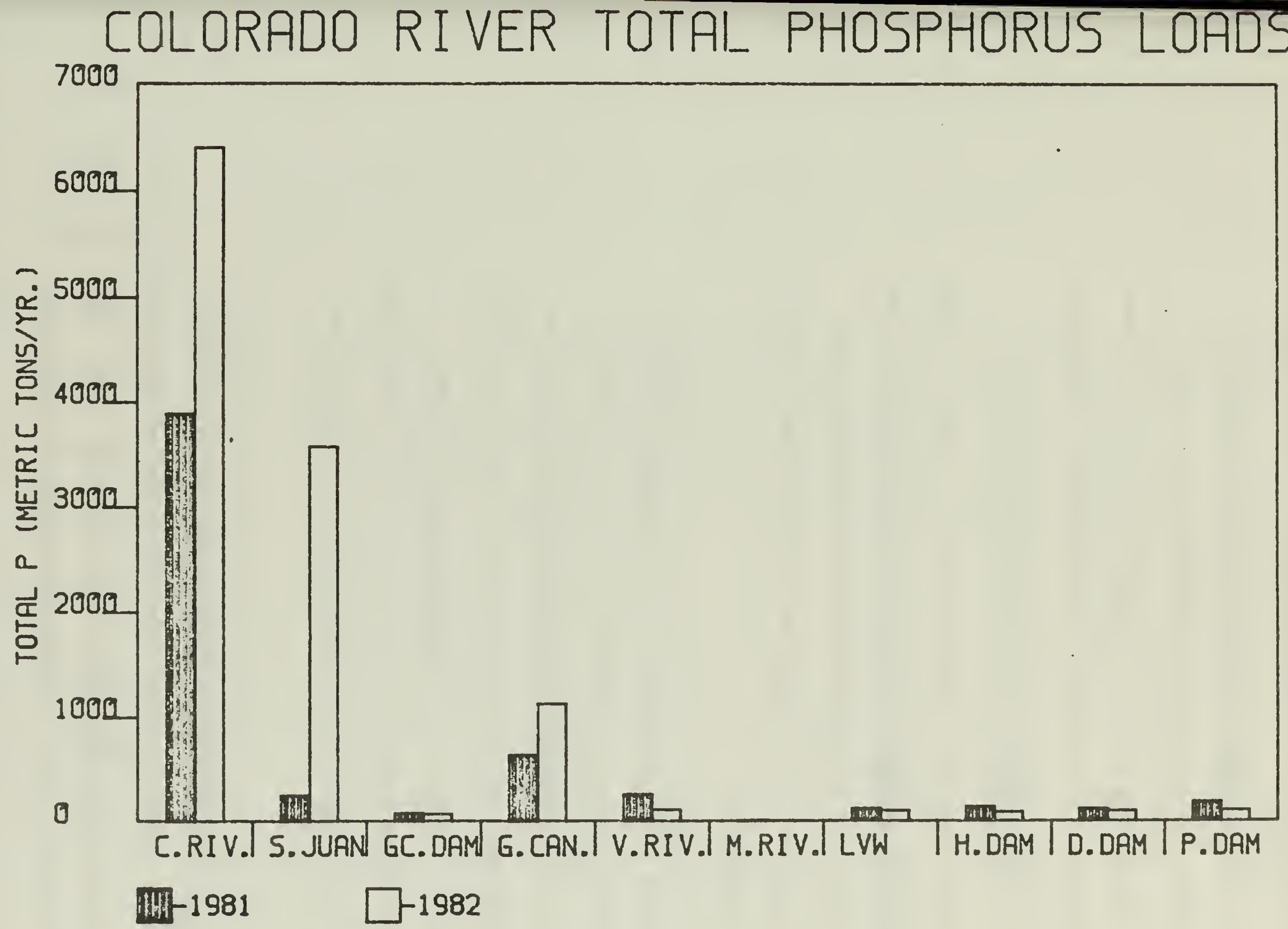

Figure 4.25 Total phosphorus loads in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

phytoplankton (Evans and Paulson 1983). This was especially true in the turbid Colorado River inflow to Lake Powell. Bio-available phosphorus loads were estimated for the main stem and tributary locations from methods described by Evans and Paulson (1983). Bio-available phosphorus followed the same spatial and annual trends as total phosphorus (Fig. 4.26). Bio-available phosphorus loads were high in the Colorado River inflow to Lake Powell (Fig. 4.26). The bio-available phosphorus loads were also high in the San Juan River during 1982.

Bio-available phosphorus loads decreased to about 50 t/yr. at Glen Canyon Dam, increased slightly at Grand Canyon and then decreased at main stem locations downstream from there (Fig. 4.26). Las Vegas Wash was a significant source of bio-available phosphorus to Lake Mead.

A relatively small percentage of the phosphorus loads in the Colorado River inflow to Lake Powell was in the form of orthophosphorus. Orthophosphorus loads in the Colorado River inflow to Lake Powell totaled only 25 t/yr. in 1981 (Fig 4.27). This increased to 70 t/yr. in 1982, which was still low considering the large volume of the inflow. The San Juan River contributed about one-half the orthophosphorus loads to Lake Powell.

Orthophosphorus loads were about 40 t/yr. at Glen Canyon Dam. There was a slight increase in orthophosphorus loads at Grand Canyon, again due to inputs from tributaries. The Virgin and Muddy Rivers were minor sources of orthophosphorus to Lake Mead. Las Vegas Wash was the principal input of orthophosphorus

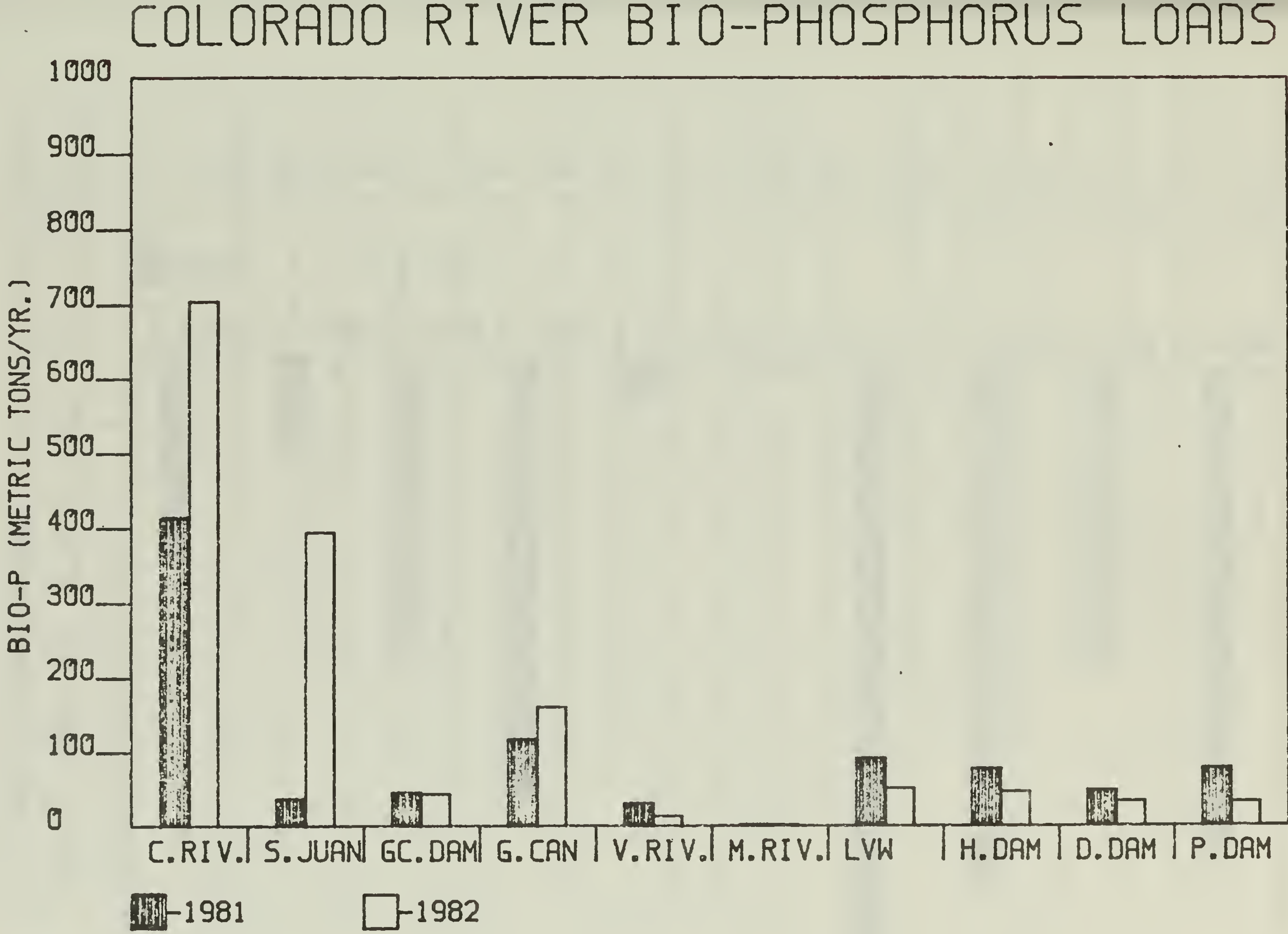

Figure 4.26 Biologically-available phosphorus loads in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

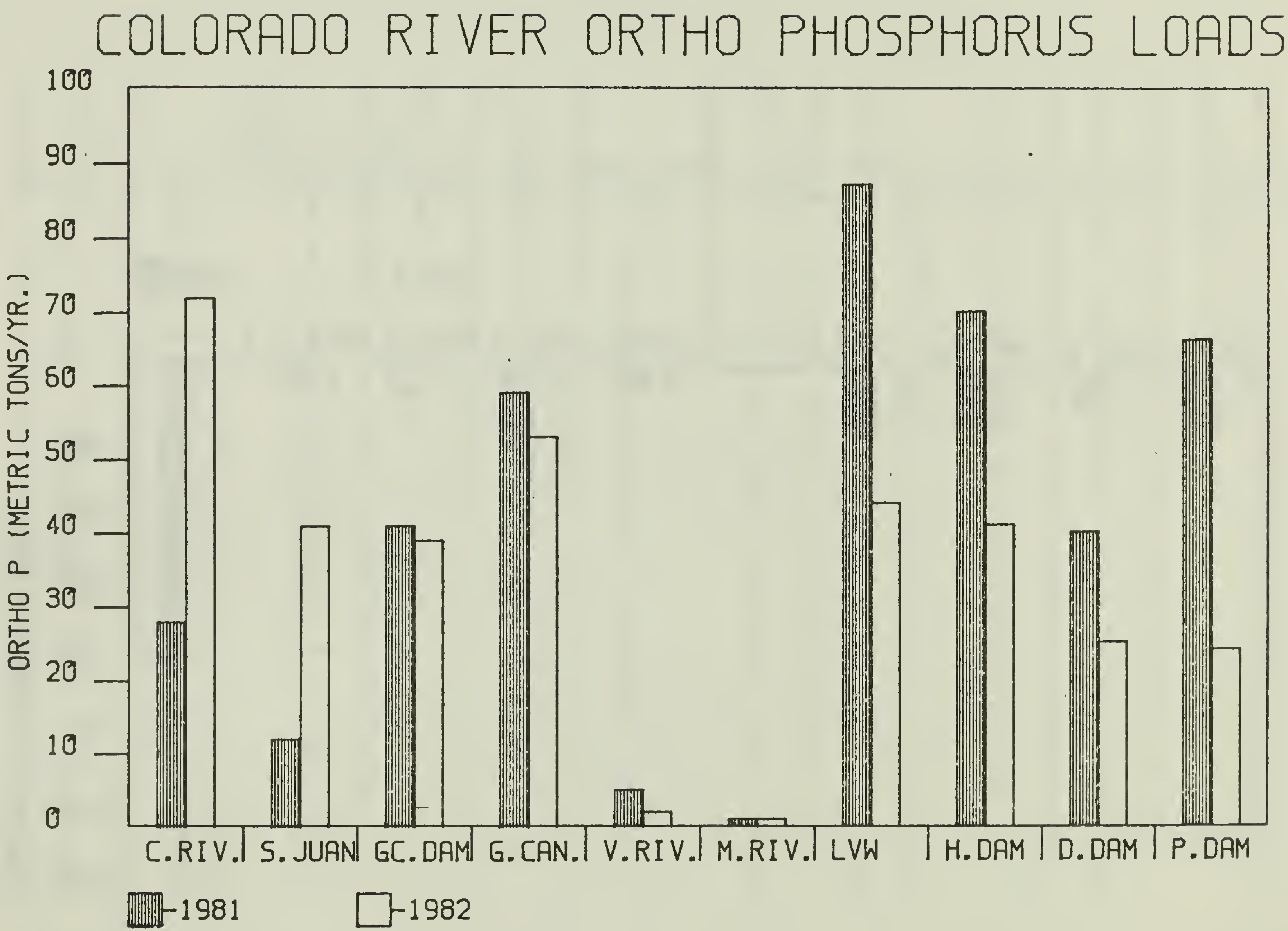

Figure 4.27 Orthophosphorus loads in the main stem and tributary reservoir inflows and discharges from dams in the Colorado River during 1981 and 1982.

to the river in 1981 (Fig. 4.27). A large percentage of this input was discharged at Hoover Dam and transported into Lake Mohave and Lake Havasu. Orthophosphorus loads in Las Vegas Wash decreased considerably in 1982 due to phosphorus removal at the City of Las Vegas and Clark County Wastewater Treatment Plants. This also caused a decrease in orthophosphorus loads at Hoover Dam and Davis Dam (Fig. 4.27). Orthophosphorus loads at Parker Dam were higher than those at Davis Dam during 1981, but loads were similar in 1982. The cause for this difference is not known, but probably reflects annual differences in orthophosphorus loading from the Bill Williams River.

The annual nutrient budgets for each reservoir are presented in Table 4.1. Total and bio-available phosphorus retention exceeded 90% in Lake Powell during both years of the study. Orthophosphorus retention was -2.5% in 1981 and 65.5% in 1982. This largely reflects the great difference in orthophosphorus inputs from the Colorado River during the two years. Orthophosphorus concentrations were extremely low throughout the river, and loads were determined primarily by the inflow or discharge volumes. Runoff into Lake Powell was extremely low in 1981 and high in 1982. However, discharges from Glen Canyon Dam were normal which resulted in similar losses of orthophosphorus from the reservoir during both years. This was also the case for total and bio-available phosphorus. The nutrient budget also showed a net loss for inorganic nitrogen in 1981. This, again, was due to low runoff in that year. Total nitrogen retention was 32.7% in 1981 and 59.4% in 1982.

Table 4.1. Nutrient Budgets for Lake Powell, Lake Mead, Lake Mohave and Lake Havasu during 1981 and 1982.

	Nutrient (metric tons/year)									
	Orthophosphorus		Bio-available phosphorus		Total phosphorus		Inorganic Nitrogen		Total Nitrogen	
Reservoir	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Lake Powell										
Input	40	113	451	1100	4143	9981	3018	6269	9222	15866
Output	41	39	45	43	79	74	3385	4402	6205	6435
% Retention	-2.5	65.5	90.0	96.1	98.1	99.3	-12.2	29.8	32.7	59.4
Lake Mead										
Input	152	100	238	224	1008	1336	4651	4661	8637	7887
Output	70	41	77	46	138	89	3586	2852	4978	4347
% Retention	53.9	59.0	67.6	79.5	86.3	93.3	22.9	38.8	42.4	44.9
Lake Mohave										
Input	70	41	77	46	138	89	3586	2852	4978	4347
Output	40	25	48	33	116	99	2269	1940	3886	4031
% Retention	42.9	39.0	37.7	28.3	15.9	-11.2	36.7	31.9	21.9	7.3
Lake Havasu										
Input	40	25	48	33	116	99	2269	1940	3886	4031
Output	66	24	78	32	189	108	1298	1192	3181	2800
% Retention	-65.0	4.0	-62.5	3.0	-62.9	-9.1	42.8	38.6	18.1	30.5

Total phosphorus retention in Lake Mead was 86.3% in 1981 and 93.3% in 1982 (Table 4.1). Bio-available phosphorus retention was 67.6% in 1981 and 79.5% in 1982. Orthophosphorus retention was about 55% of both years. Inorganic nitrogen retention in Lake Mead was 22.9% in 1981 and 38.8% in 1982. Total nitrogen retention was about 43% in both years (Table 4.1).

Nutrient retention decreased considerably in the downstream reservoirs. Total phosphorus retention was 15.9% in Lake Mohave in 1981 and -11.2% in 1982. Bio-available phosphorus retention was 37.7% in 1981 and 28.3% in 1982. Orthophosphorus retention in Lake Mohave was about 40% in both years (Table 4.1). The apparent net loss of total phosphorus from Lake Mohave in 1982 seems to be due to decreased phosphorus loading from Las Vegas Wash and Hoover Dam. Inorganic nitrogen retention in Lake Mohave was about 35% in both years. Total nitrogen retention was 21.9% in 1981 and 7.3% in 1982.

The nutrient budget for Lake Havasu may not be indicative of true conditions because the Bill Williams River was not sampled during our study. Inputs from that river were probably the main reason why the budget indicates a net loss of phosphorus for 1981 and such low retention in 1982. Inorganic nitrogen retention in Lake Havasu was slightly higher than in Lake Mohave. Total nitrogen retention in 1981 was comparable to Lake Mohave, but retention in Lake Havasu was higher in 1982.

4.5 Reservoir Nutrient Concentrations

Total phosphorus concentrations in the reservoirs were highest in the headwaters of Lake Powell (Fig. 4.28). Total phosphorus concentrations averaged about .017 mg/l at Hite (1a) during 1981 and 1982. Total phosphorus decreased at downstream stations in 1981. In 1982, total phosphorus concentrations were relatively high at Hall's Crossing (3) and showed some increase at Wahweap Bay (5).

Total phosphorus concentrations in the main basin areas of Lake Mead were highest at Iceberg Canyon (9a) (Fig. 4.28). Total phosphorus concentrations decreased downstream at Temple Basin (10) and Virgin Basin (11) and increased again in Boulder Basin (15). The higher concentrations in Boulder Basin were due to loading from Las Vegas Wash. A large part of the Las Vegas Wash inflow was transmitted into Lake Mohave from Hoover Dam. Total phosphorus concentrations averaged about .017 mg/l at Eldorado Canyon in 1981. Total phosphorus concentrations remained relatively high (.010 - .015 mg/l) at downstream stations in Lake Mohave and Lake Havasu during 1981. Total phosphorus concentrations at Eldorado Canyon were much lower in 1982. Total phosphorus concentrations were, however, similar at Cottonwood Basin (18) and Katherine's Landing (19) and the Lake Havasu stations (Fig. 4.28).

Orthophosphorus concentrations were extremely low throughout the river system (Fig. 4.29). Orthophosphorus concentrations only exceeded .002 mg/l at Hite (1a), in 1982, at Boulder Basin (15) in both years, at Eldorado Canyon (17b) in 1982 and in middle and lower Lake Havasu in 1981.

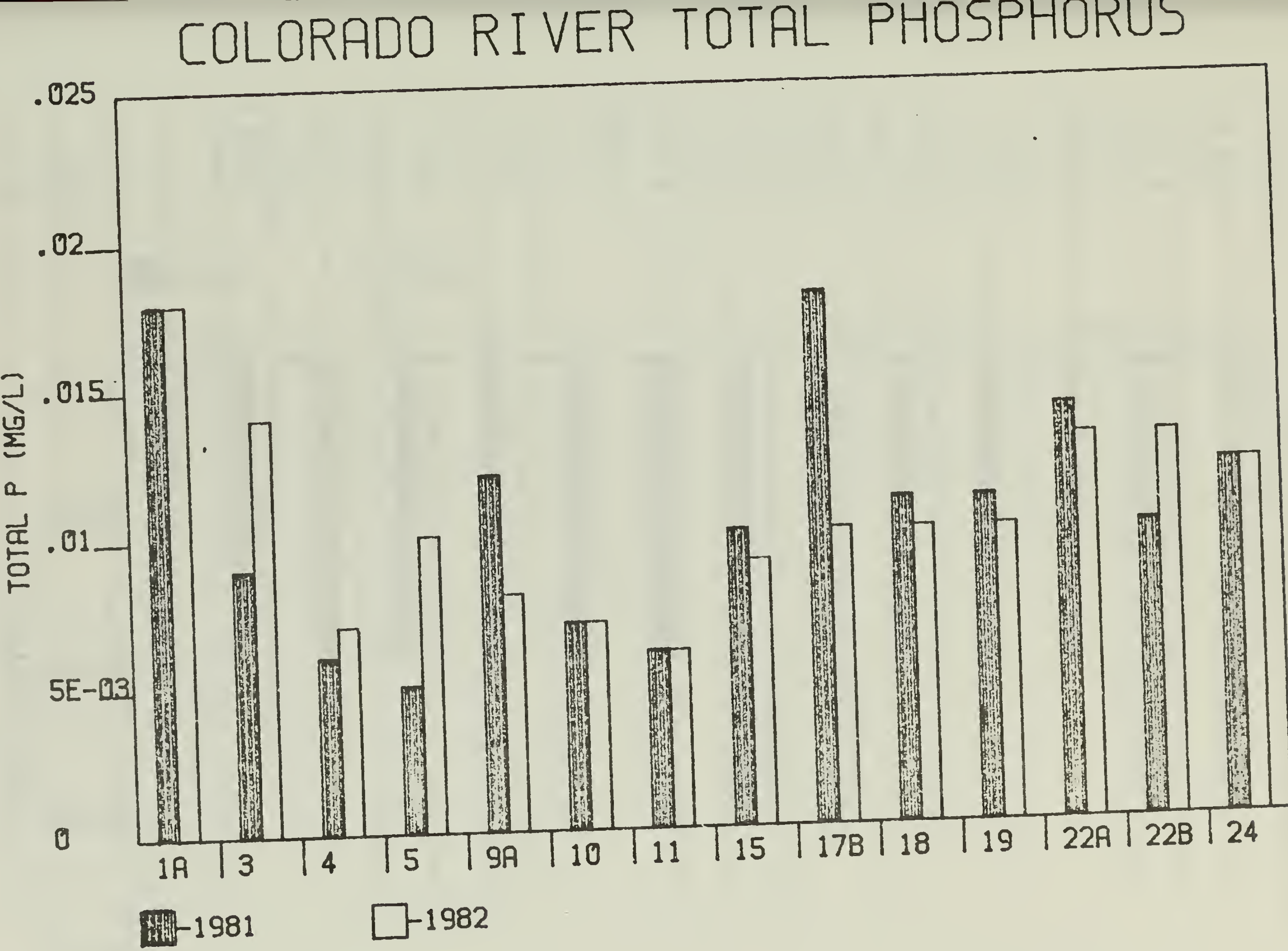

Figure 4.28 Average total phosphorus concentrations in 0-5m integrated depths at select reservoir locations in Lake Powell (1a, 3, 4, 5), Lake Mead (9a, 10, 11, 15), Lake Mohave (17b, 18, 19) and Lake Havasu (22a, 22b, 24) during 1981 and 1982.

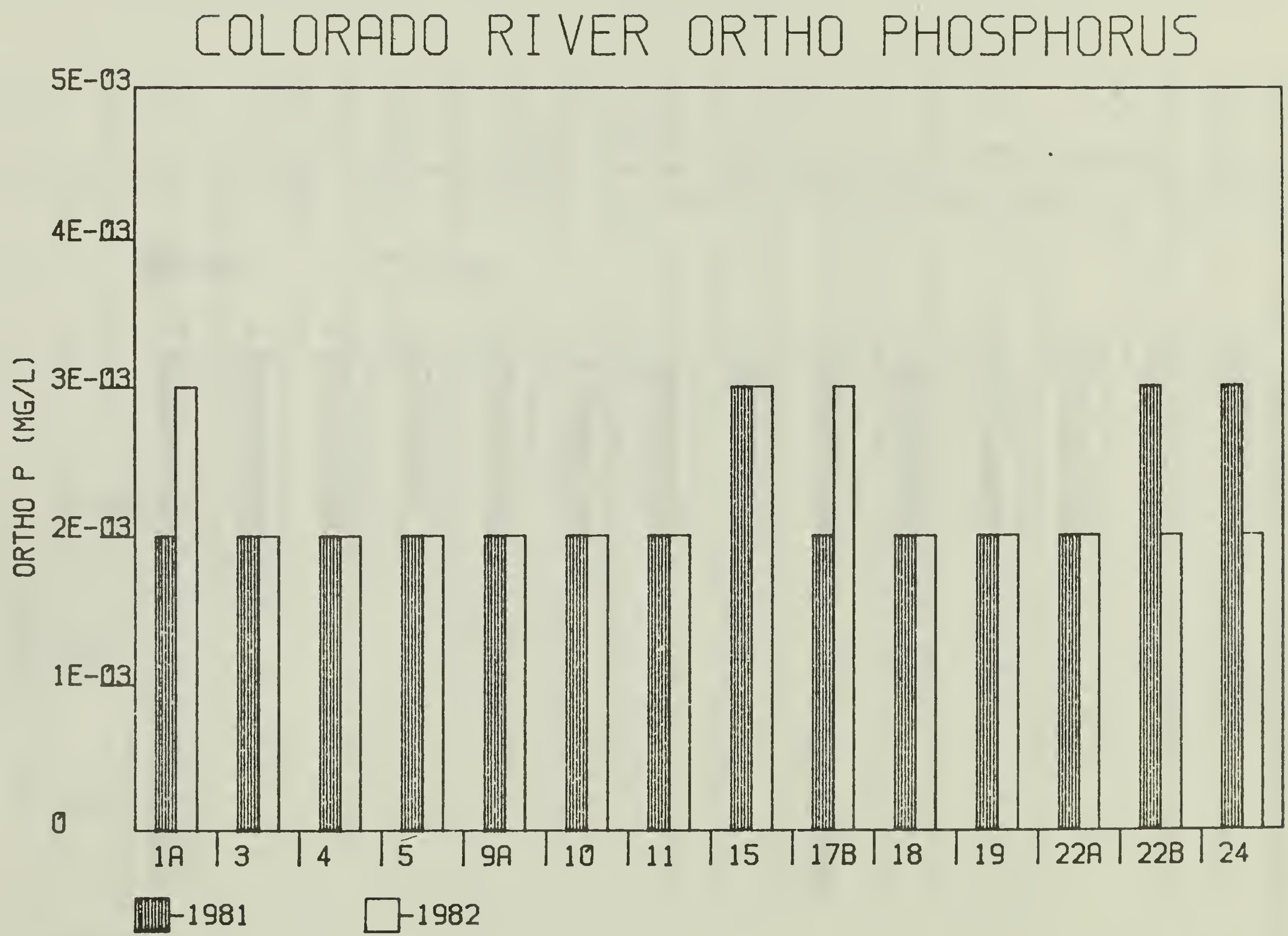

Figure 4.29 Average orthophosphorus concentrations in 0-5m integrated depths at select reservoir locations in Lake Powell (1a, 3, 4, 5), Lake Mead (9a, 10, 11, 15), Lake Mohave (17b, 18, 19) and Lake Havasu (22a, 22b, 24) during 1981 and 1982.

Inorganic nitrogen concentrations (primarily nitrate) showed a fairly steady decrease from the headwaters of Lake Powell to Parker Dam (Fig. 4.30). Inorganic nitrogen concentrations in Lake Powell were higher in 1982 than 1981. This was due to the higher loading that occurred during spring runoff in 1982. Average inorganic nitrogen concentrations were similar at stations in Lake Mead, Lake Mohave and Lake Havasu during 1981 and 1982 (Fig. 4.30).

Total nitrogen concentrations followed similar trends in the reservoir system (Fig. 4.31). In 1982, total nitrogen concentrations decreased steadily downstream from Hite (1a) to Wahweap (5). Total nitrogen concentrations did not change appreciably in Lake Mead or Lake Mohave, but decreased slightly in lower Lake Havasu (24) (Fig. 4.31). The pattern was similar in 1981, except for the high total nitrogen value at Wahweap (5) (Fig. 4.31).

Total phosphorus and nitrate (+ nitrite) concentrations were the only nutrients that showed marked seasonal patterns in the reservoirs. Total phosphorus concentrations in Lake Powell were usually highest at Hite (1a) (Fig. 4.32). Total phosphorus concentrations at Hite showed an increase during spring and early summer, particularly in 1982. Total phosphorus concentrations decreased and were less variable at stations downstream from Hite. On a few occasions, total phosphorus concentrations increased sharply at downstream stations. Total phosphorus was over .050 mg/l at Hall's Crossing (3) during May and about .045 mg/l at Wahweap (5) in August. There was also a

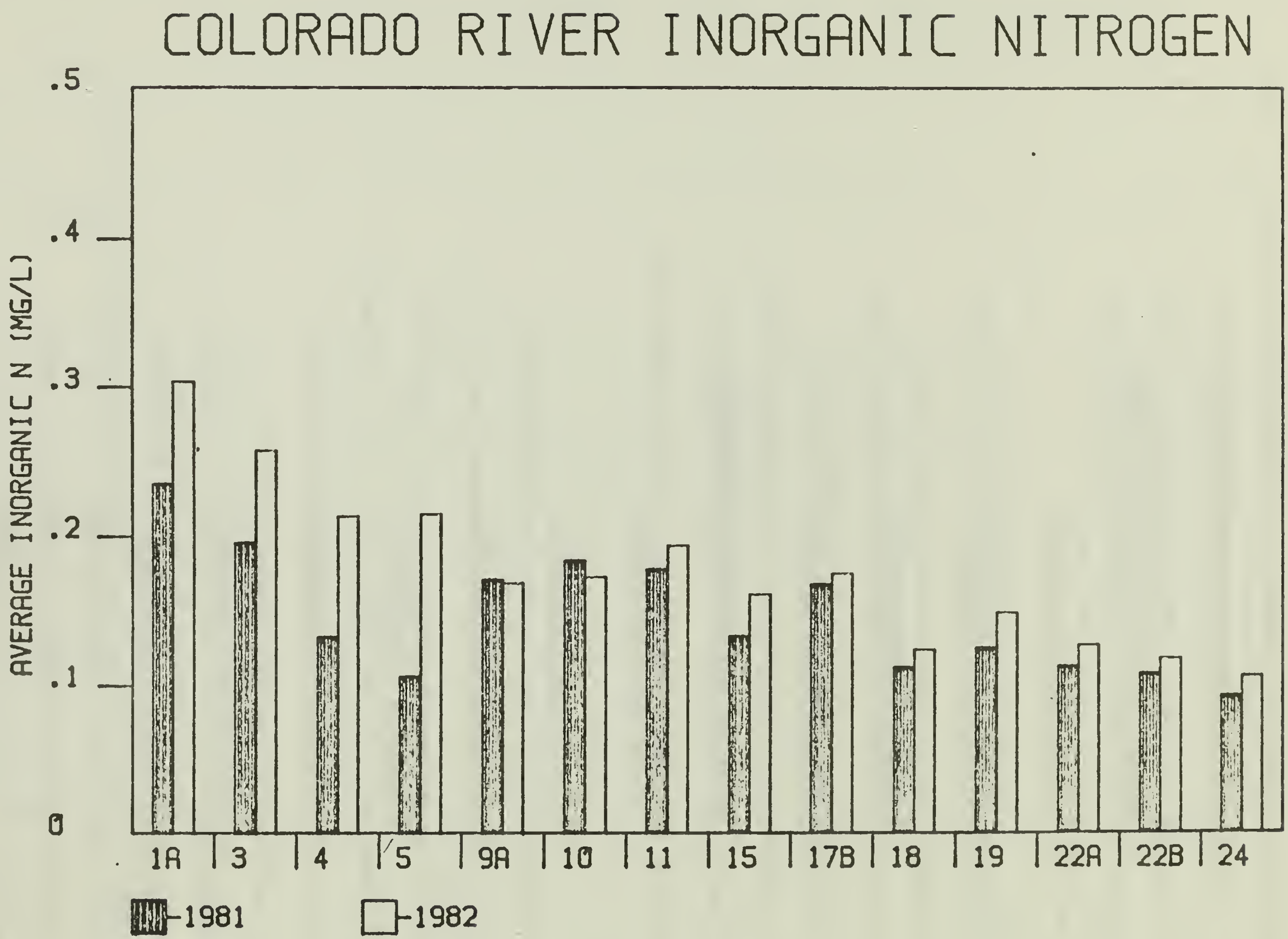

Figure 4.30 Average dissolved inorganic nitrogen concentrations in 0-5m integrated depths at select reservoir locations in Lake Powell (1a, 3, 4, 5), Lake Mead (9a, 10, 11, 15), Lake Mohave (17b, 18, 19) and Lake Havasu (22a, 22b, 24) during 1981 and 1982.

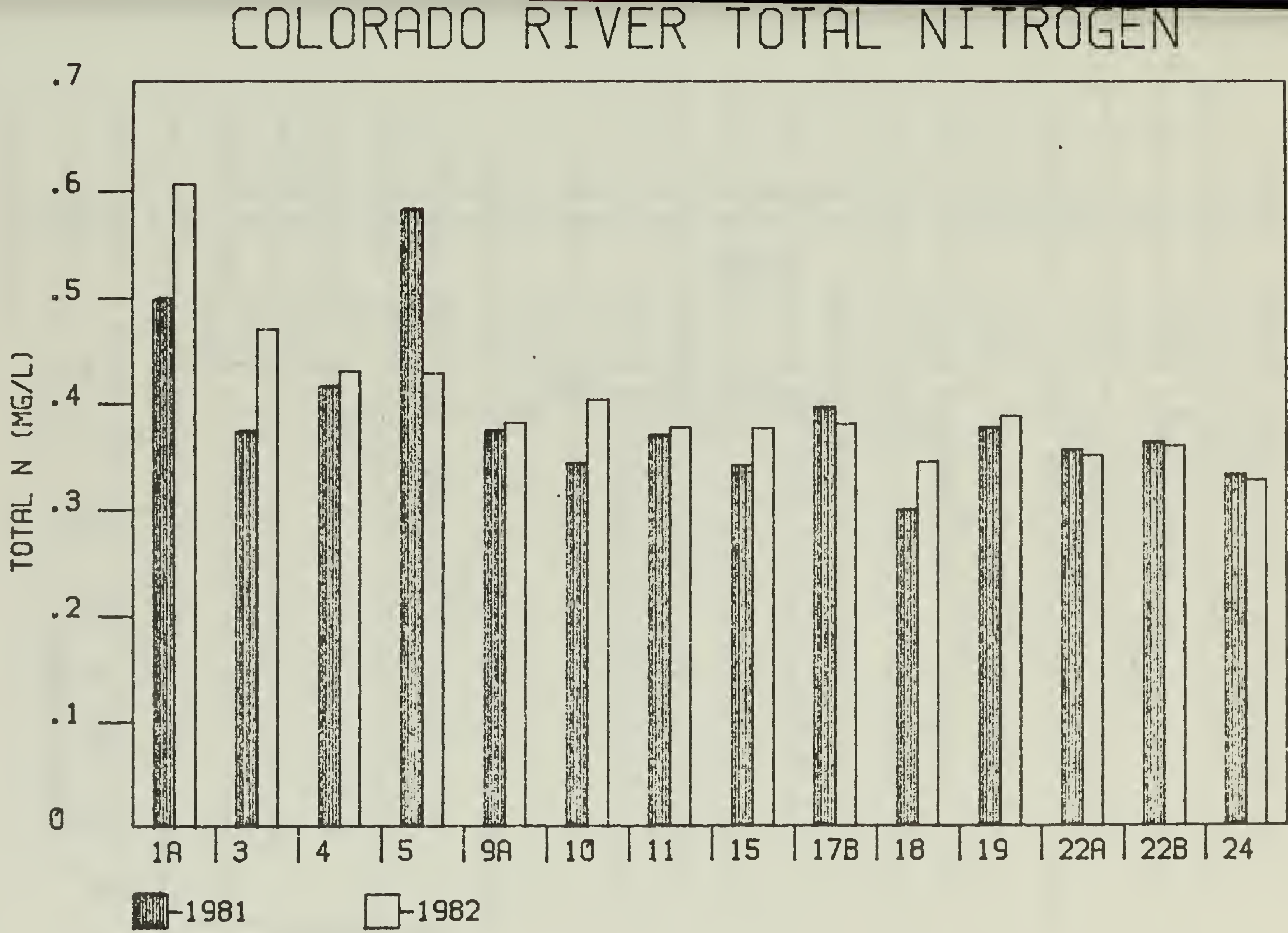

Figure 4.31 Average total nitrogen concentrations in 0-5m integrated depths at select locations in Lake Powell (1a, 3, 4, 5), Lake Mead (9a, 10, 11), Lake Mohave (17b, 18, 19) and Lake Havasu (22a, 22b, 24) during 1981 and 1932.

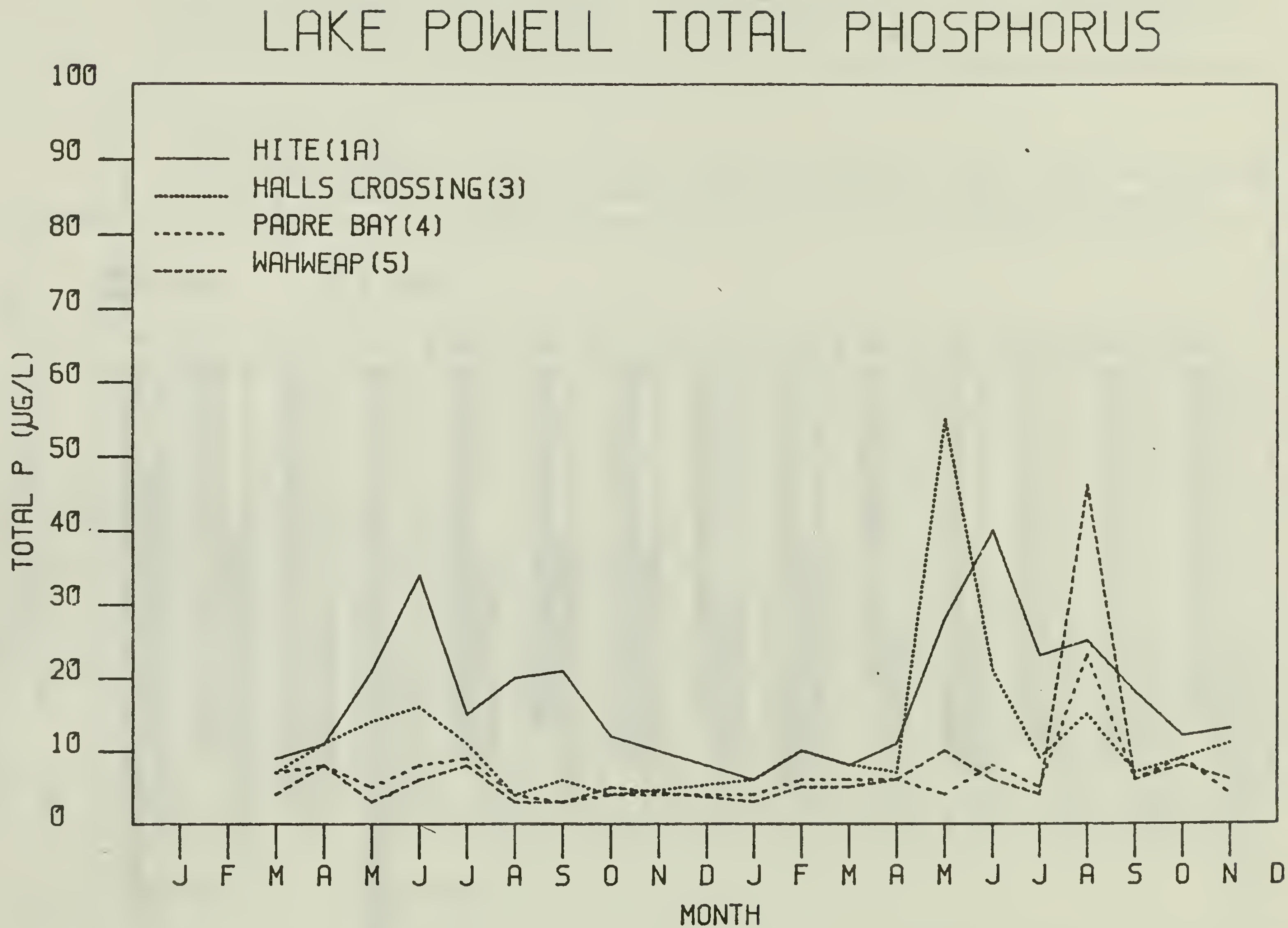

Figure 4.32 Monthly total phosphorus concentrations in 0-5m integrated depths at select locations in Lake Powell during 1981 and 1982.

slight increase in total phosphorus at Padre Bay (4) during August. These peaks may reflect phosphorus inputs from the spring overflow as it moved downstream.

Nitrate (+ nitrite) concentrations in Lake Powell were generally high during the winter and spring and low during the summer and fall months (Fig. 4.33). The highest concentrations occurred at Hite (1a) and ranged up to .42 mg/l. A similar seasonal pattern in nitrate was evident at all stations. Nitrate concentrations decreased during the spring and early summer, reached minimum during summer and then increased again in fall. In 1981, nitrate was depleted to low levels at Wahweap (5) and Padre Bay (4) (Fig. 4.33). Nitrate concentrations during the winter were similar at all stations, although Hite (1a) was generally highest. It is not known what caused the the large peak in nitrate at Wahweap (5) in August, 1982. It coincided with a similar peak in total phosphorus indicating that perhaps it is related to the spring overflow.

Total phosphorus concentrations in Lake Mead were generally very low (Fig. 4.34). Total phosphorus reached .035 mg/l at Iceberg Canyon (9a) in August, 1981. Otherwise, concentrations were below .020 mg/l and averaged about .005 mg/l at most locations. The variability in total phosphorus in upstream locations seemed to be due to seasonal variations in discharges from Grand Canyon or inputs from flash floods. Total phosphorus concentrations in Boulder Basin were usually higher than other main reservoir stations (Fig. 4.34) due to phosphorus inputs from Las Vegas Wash.

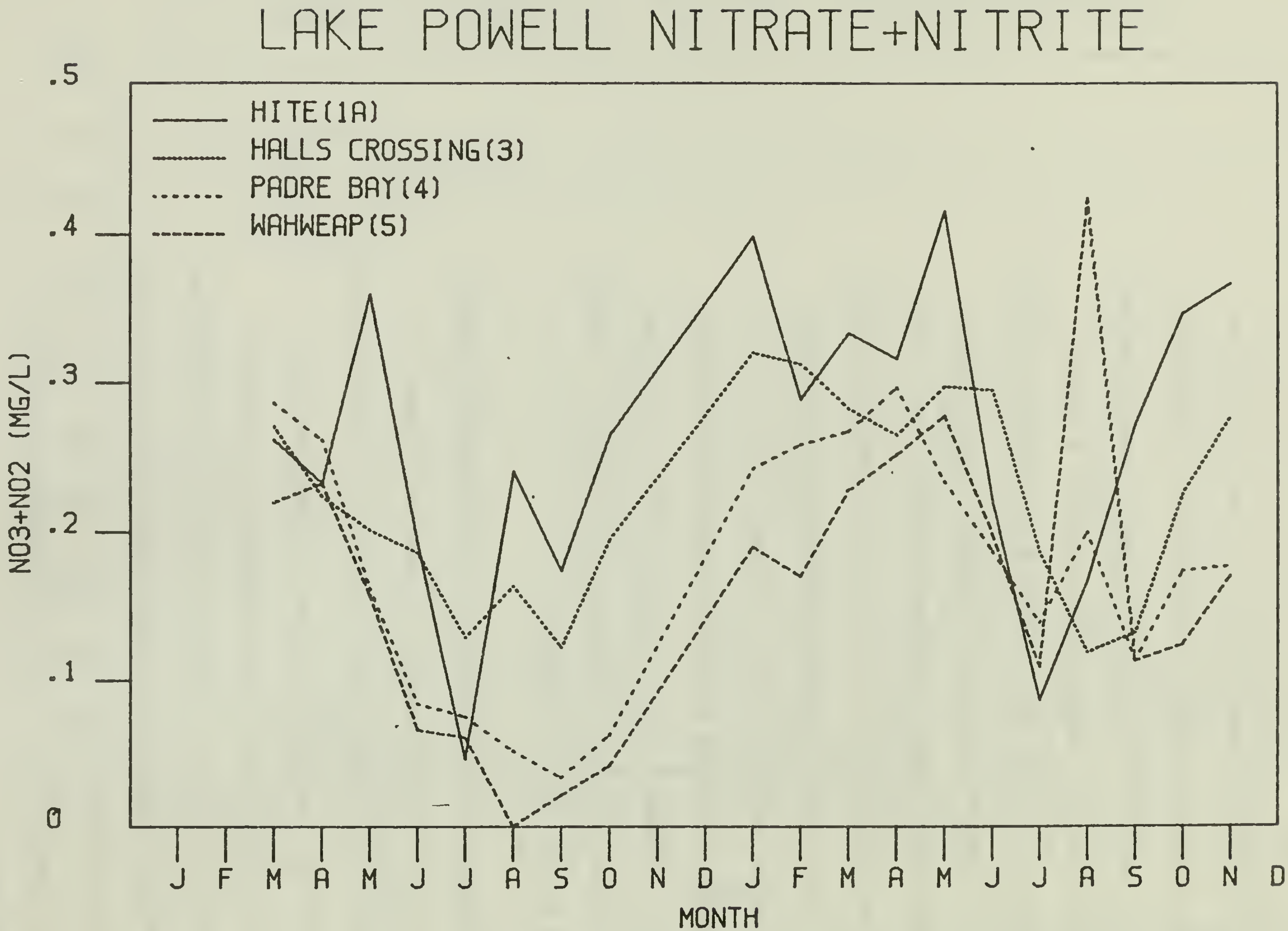

Figure 4.33 Monthly nitrate + nitrite concentrations in 0-5m integrated depths at select locations in Lake Powell during 1981 and 1982.

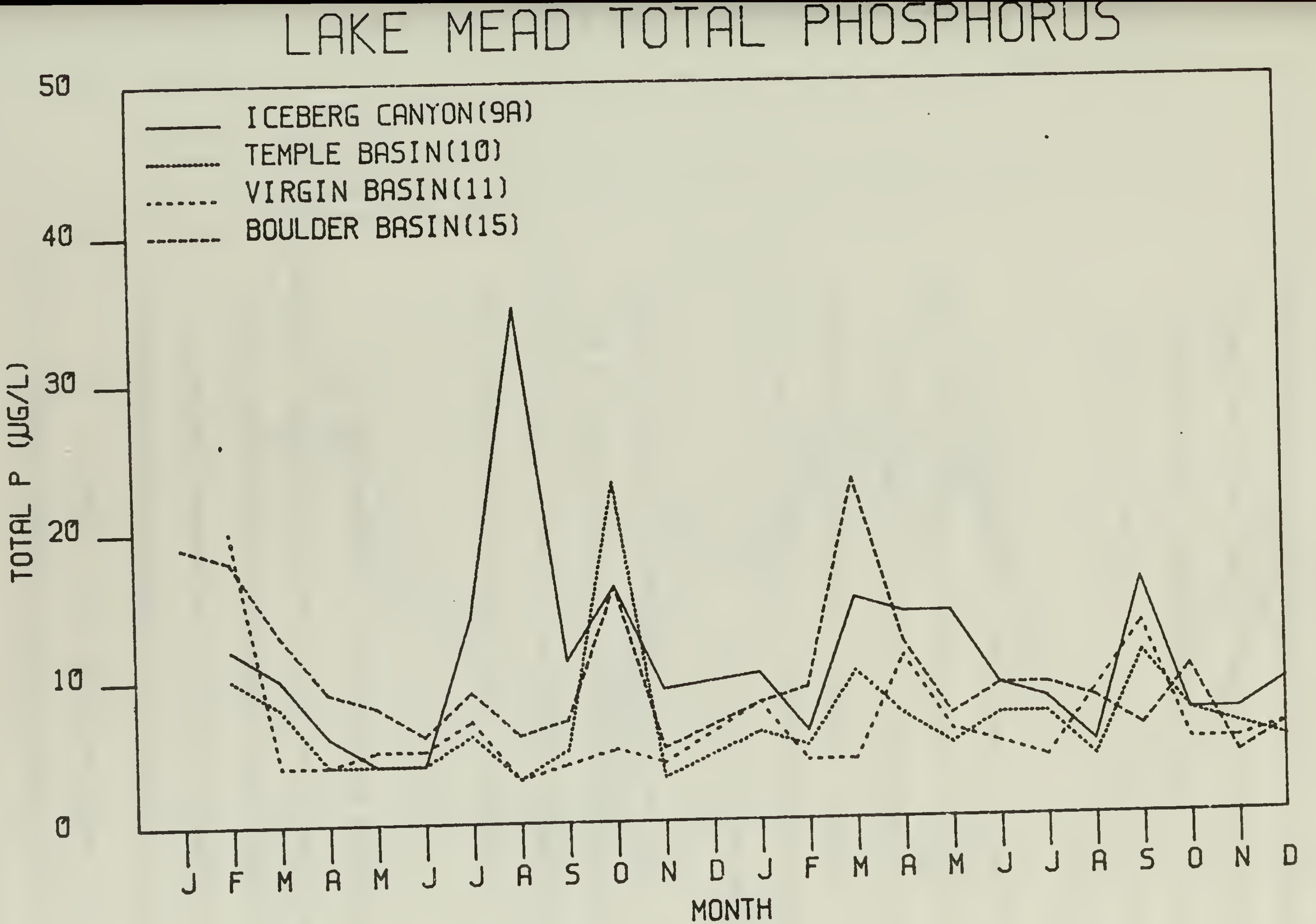

Figure 4.34 Monthly total phosphorus concentrations in 0-5m integrated depths at select locations in Lake Mead during 1981 and 1982.

There was a definite seasonal pattern in nitrate (+ nitrite) concentrations in Lake Mead (Fig. 4.35). Nitrate concentrations were high during the winter and early spring, decreased during May through September and then increased again in fall. Nitrate concentrations in Boulder Basin decreased to non-detectable levels during June-September, 1981. Nitrate concentrations in Boulder Basin were similar to the other stations during 1982.

Total phosphorus concentrations in Lake Mohave were generally low except for early months of the study (Fig. 4.36). Total phosphorus reached about .030 mg/l in June, 1981 at Eldorado Canyon (17b). Throughout the remainder of the study, total phosphorus concentrations averaged about .010 mg/l at all stations in Lake Mohave (Fig. 4.36).

Nitrate (+ nitrite) concentrations in Lake Mohave showed seasonal patterns similar to those in Lake Mead (Fig. 4.37). However, in Lake Mohave nitrate was virtually exhausted from the epilimnion of the reservior during August and September (Fig. 4.37).

Total phosphorus concentrations in Lake Havasu were generally lowest during the spring and highest during the summer and fall (Fig. 4.38). Total phosphorus concentrations did not differ greatly among the stations. The seasonal patterns observed in nitrate (+ nitrite) in Lake Mead and Lake Mohave also occurred in Lake Havasu (Fig. 4.39). However, concentrations during winter months were lower than those in the upstream reservoirs.

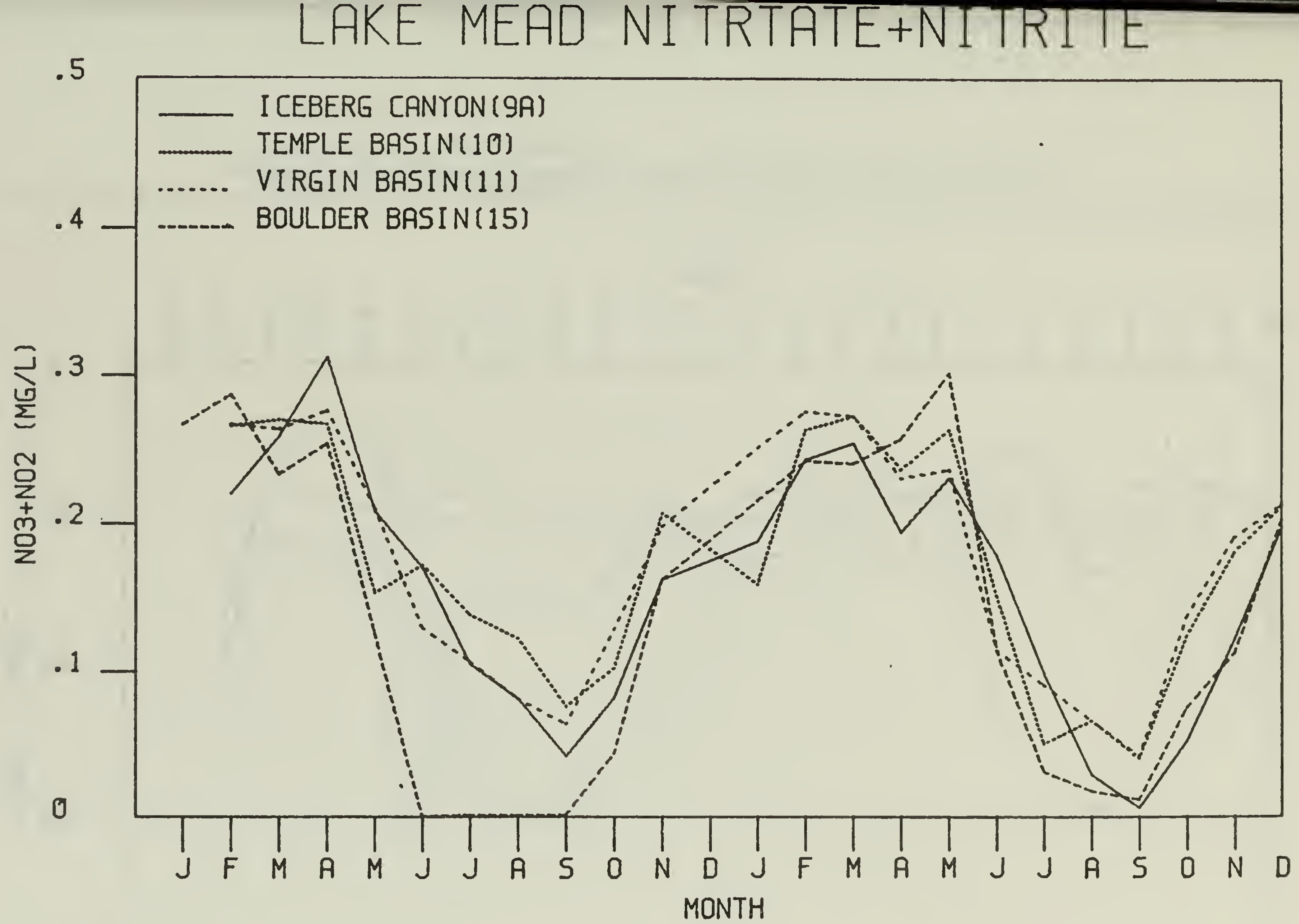

Figure 4.35 Monthly nitrate + nitrite concentrations in 0-5m integrated depths at select locations in Lake Mead during 1981 and 1982.

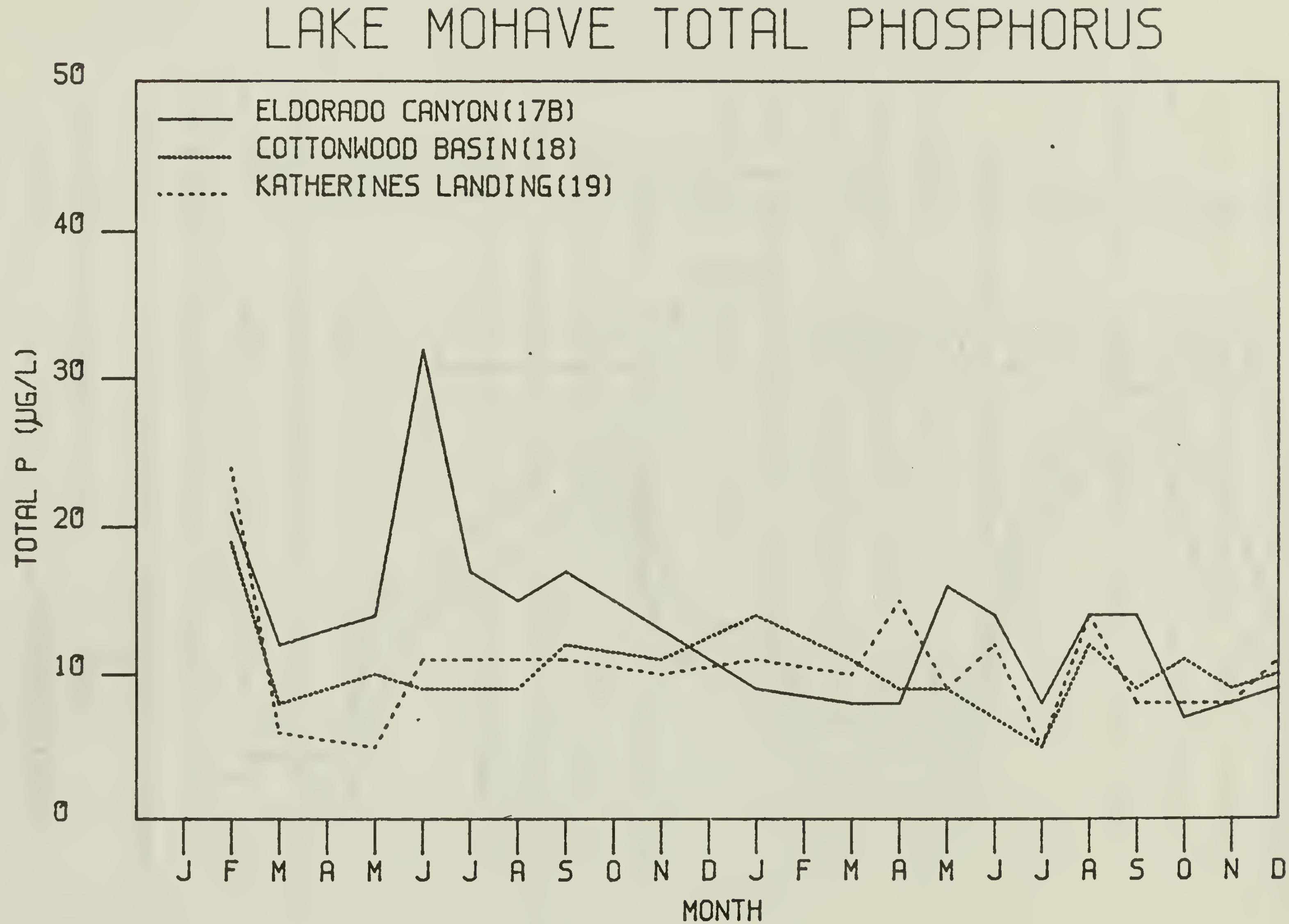

Figure 4.36 Monthly total phosphorus concentrations in 0-5m integrated depths at select locations in Lake Mohave during 1981 and 1982.

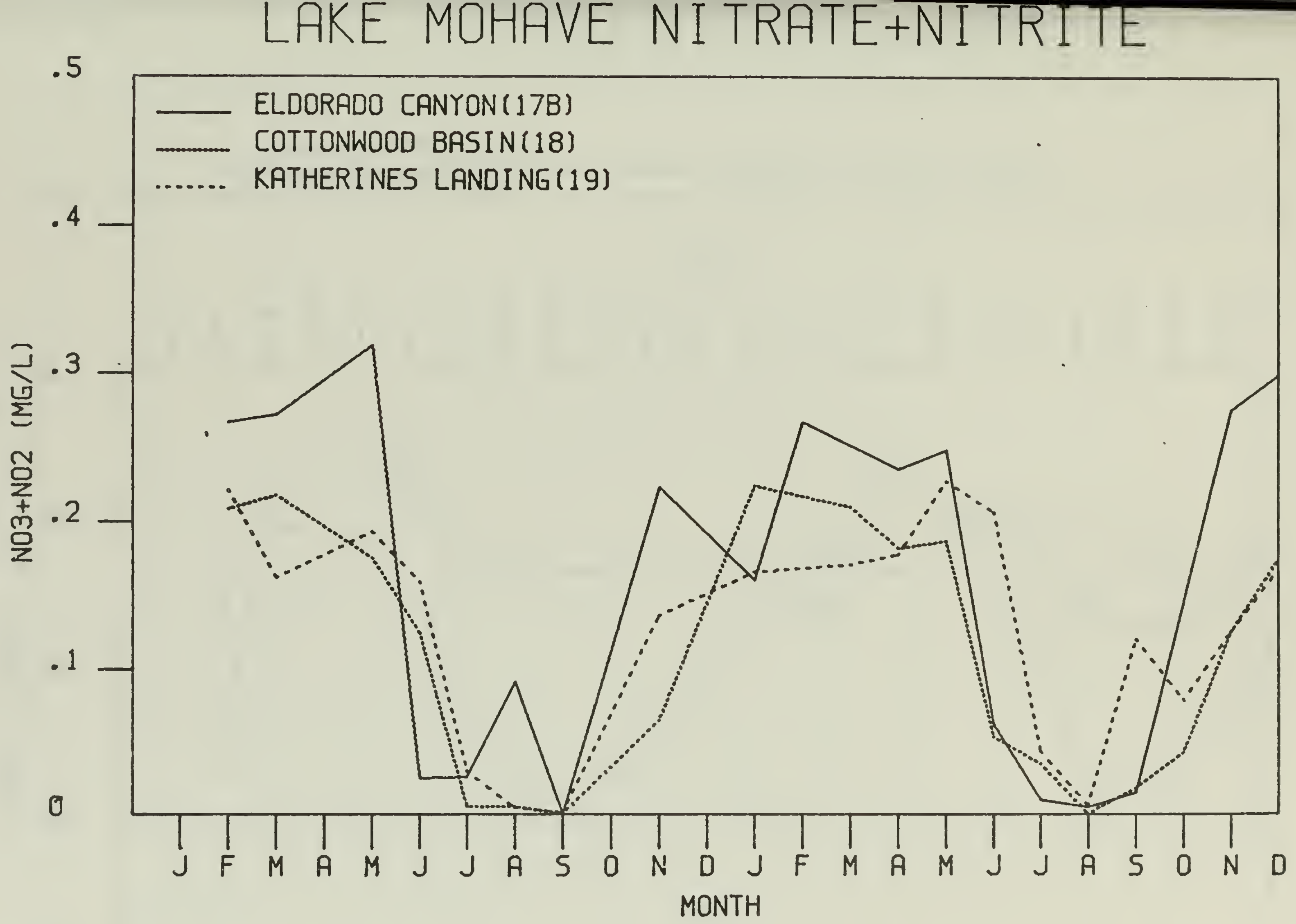

Figure 4.37 Monthly nitrate + nitrite concentrations in 0-5m integrated depths at select locations in Lake Mohave during 1981 and 1982.

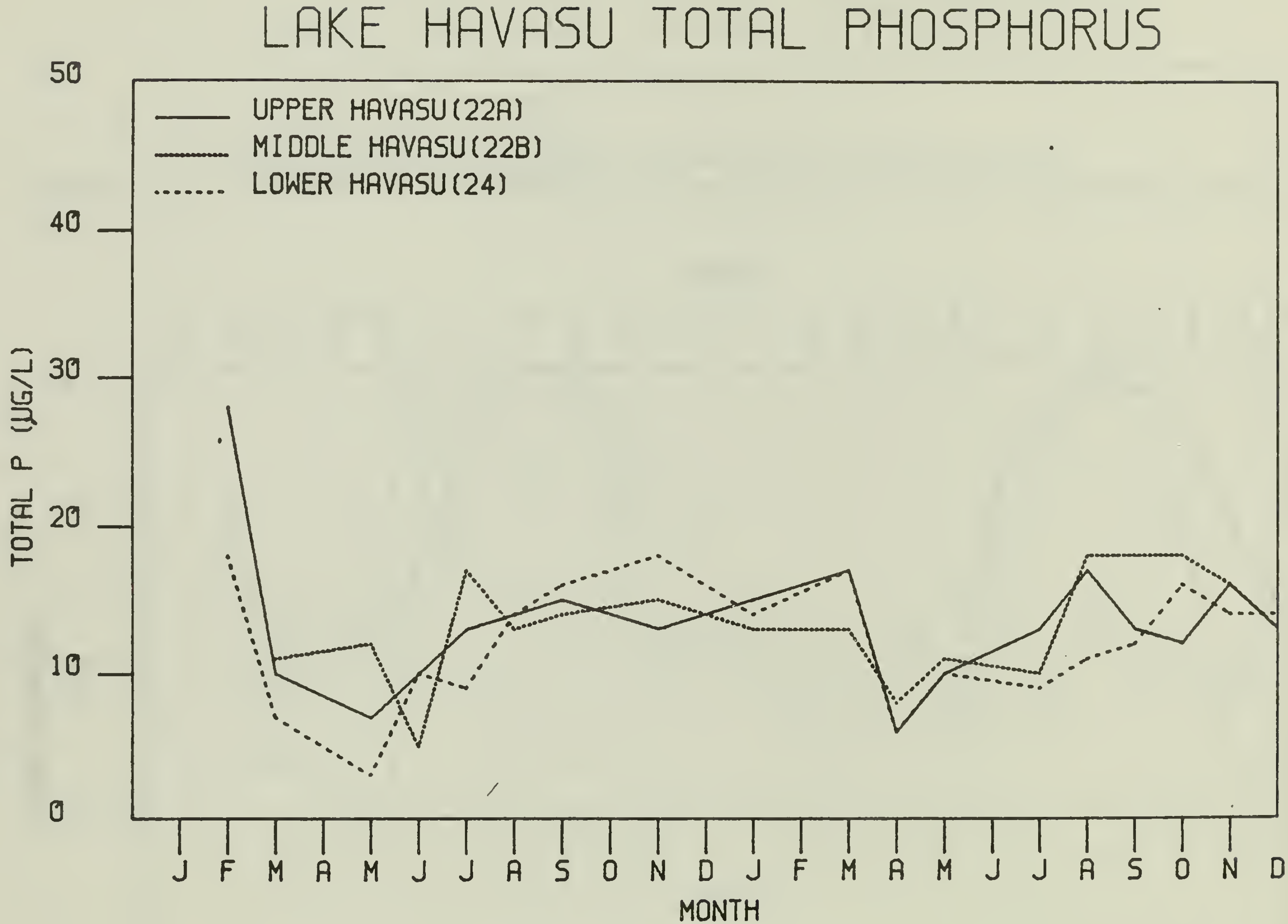

Figure 4.38 Monthly total phosphorus concentrations in 0-5m integrated depths at select locations in Lake Havasu during 1981 and 1982.

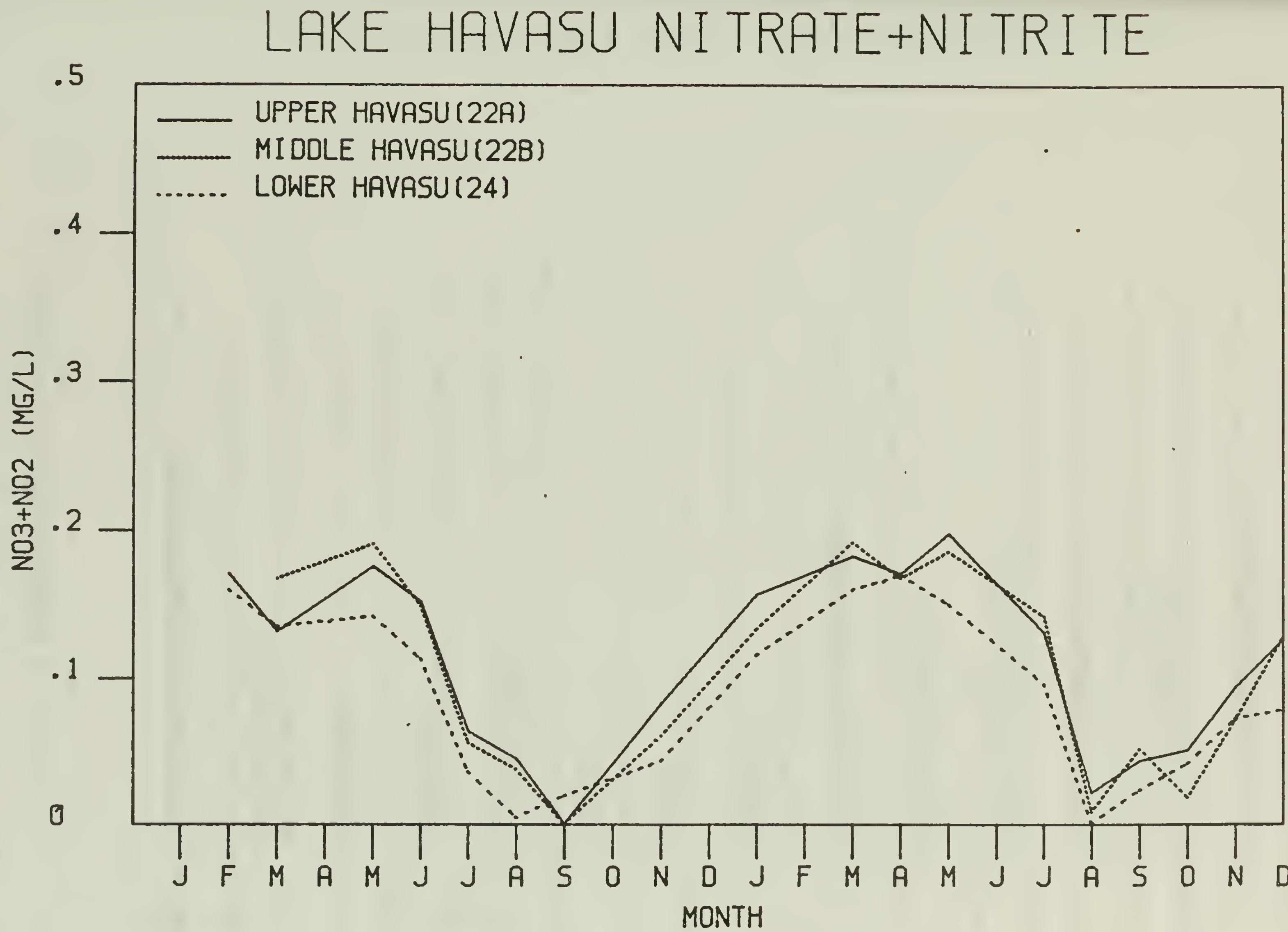

Figure 4.39 Monthly nitrate + nitrite concentrations in 0-5m integrated depths at select locations in Lake Havasu during 1981 and 1982.

4.6 Reservoir Chlorophyll-a and Productivity

Chlorophyll-a concentrations at select main reservoir stations are shown in Figure 4.40. The highest average chlorophyll-a concentrations were found at Hite (1a) in Lake Powell. Chlorophyll-a decreased from Hite (1a) downstream to Wahweap Bay (5). Chlorophyll-a averaged about 1.5 μg/l at the main reservoir stations in Lake Powell. There was not much difference in the annual average chlorophyll-a concentrations in Lake Powell during 1981 and 1982.

Average chlorophyll-a concentrations increased again at the headwaters of Lake Mead (Fig. 4.40). Chlorophyll-a averaged about 2-3 μg/l at Iceberg Canyon (9a). Chlorophyll-a concentrations in the main basin areas of Lake Mead were extremely low and averaged about 1 μg/l. Chlorophyll-a was slightly higher in Boulder Basin (15) than Virgin Basin (11).

Chlorophyll-a concentrations increased sharply below Hoover Dam at Eldorado Canyon (Fig. 4.40). In 1981, this station had one of the highest average chlorophyll-a concentrations in the river. Chlorophyll-a concentrations at Eldorado Canyon and downstream stations in Lake Mohave were lower in 1982 than in 1981 (Fig. 4.40). This may be due to the reduction in phosphorus loading from Las Vegas Wash and Hoover Dam. Chlorophyll-a concentrations in Lake Mohave averaged about 3-4 μg/l in 1981 and 2-3 μg/l in 1982.

Chlorophyll-a concentrations in Lake Havasu were comparable to or slightly higher than those in Lake Mohave (Fig. 4.40).

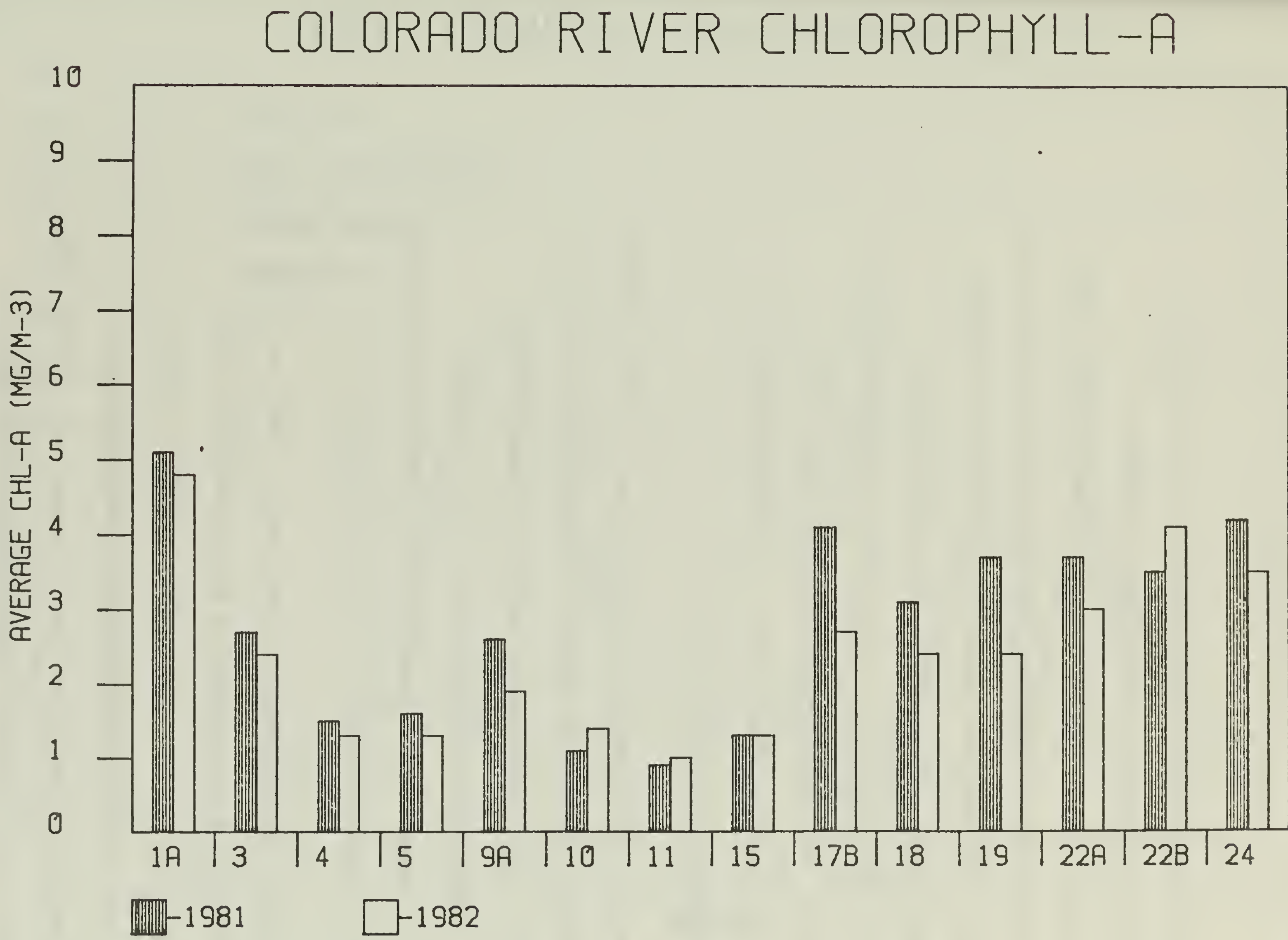

Figure 4.40 Average chlorophyll-a concentrations in 0-5m integrated depths at select locations in Lake Powell (1a, 3, 4, 5), Lake Mead (9a, 10, 11, 15), Lake Mohave (17b, 18, 19) and Lake Havasu (22a, 22b, 24) during 1981 and 1982.

Concentrations averaged 3-4 µg/l during both years of the study. Differences among the stations were possibly due to additional nutrient inputs from the Bill Williams River at downstream stations.

There was no apparent seasonal pattern in chlorophyll-a concentrations in Lake Powell (Fig. 4.41). However, a well-defined peak occurred at Hite (1a) in June-September, 1981. This was also evident in 1982, but concentrations were lower and more variable. Chlorophyll-a concentrations at Hall's Crossing (3) also showed some increase during the summer period, especially in 1982 (Fig. 4.41). Chlorophyll-a concentrations at Hall's Crossing were slighly higher in 1982 than in 1981. Chlorophyll-a concentrations at Padre Bay (4) and Wahweap (5) were low throughout the study (Fig. 4.41).

In Lake Mead chlorophyll-a concentrations at Iceberg Canyon (9a) were highest during the summer of 1981 and spring and fall of 1982 (Fig. 4.42). There was no definite seasonal pattern evident at Iceberg Canyon or elsewhere in the reservoir. Chlorophyll-a ranged from 1-3 µg/l at Temple Basin (10) and from 0.5-1.5 µg/l in Virgin Basin (11) and Boulder Basin (15).

In contrast to Lake Mead and Lake Powell, there was some seasonal variation in chlorophyll-a concentrations in Lake Mohave (Fig. 4.43) and Lake Havasu (Fig. 4.44). In these reservoirs, chlorophyll-a concentrations were high during winter, decreased in spring and then increased and remained high during summer, fall and early winter. This pattern was consistent in both reservoirs during both years of the study.

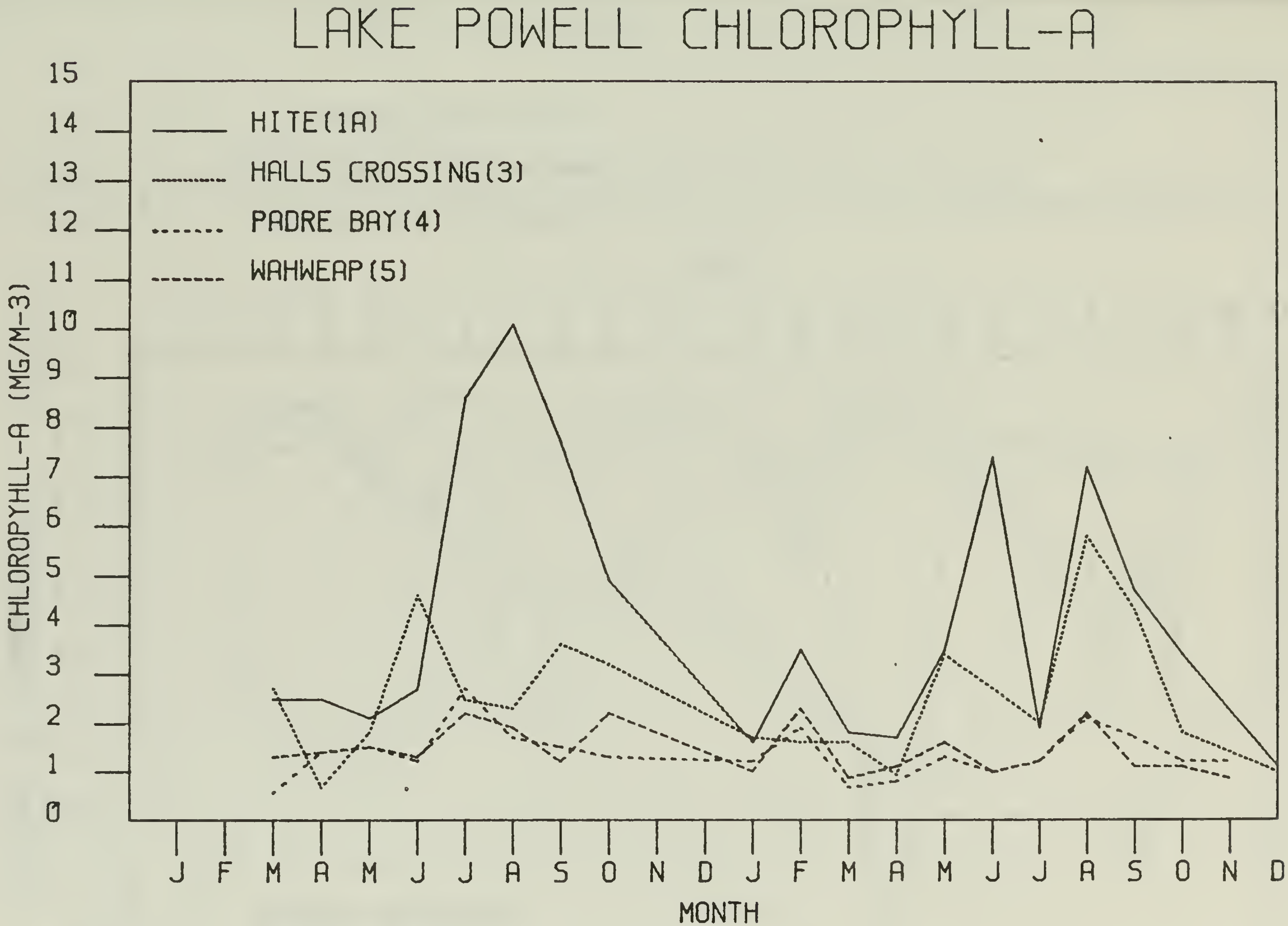

Figure 4.41 Monthly chlorophyll-a concentrations in 0-5m integrated depths at select locations in Lake Powell during 1981 and 1982.

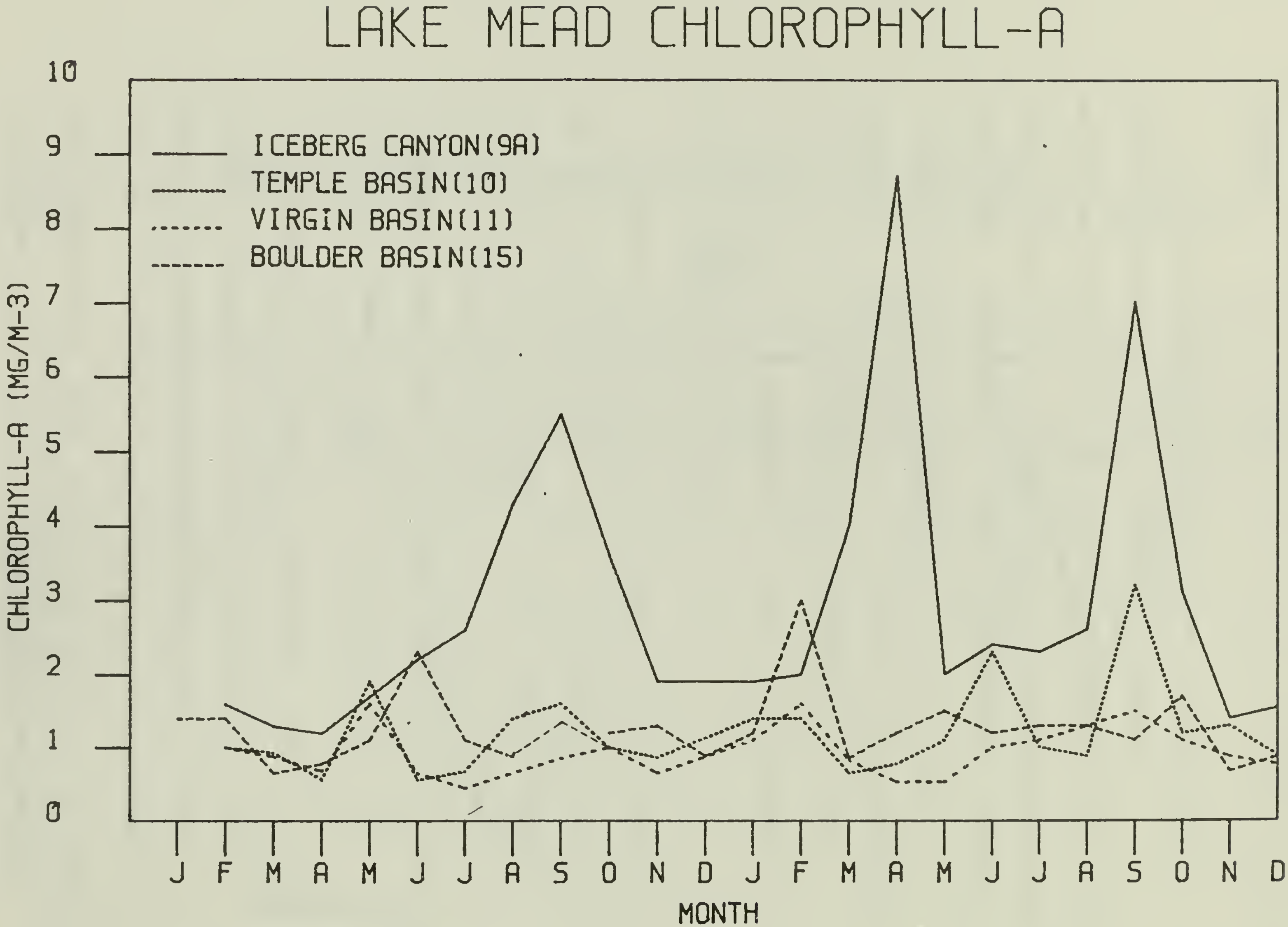

Figure 4.42 Monthly chlorophyll-a concentrations in 0-5m integrated depths at select locations in Lake Mead during 1981 and 1982.

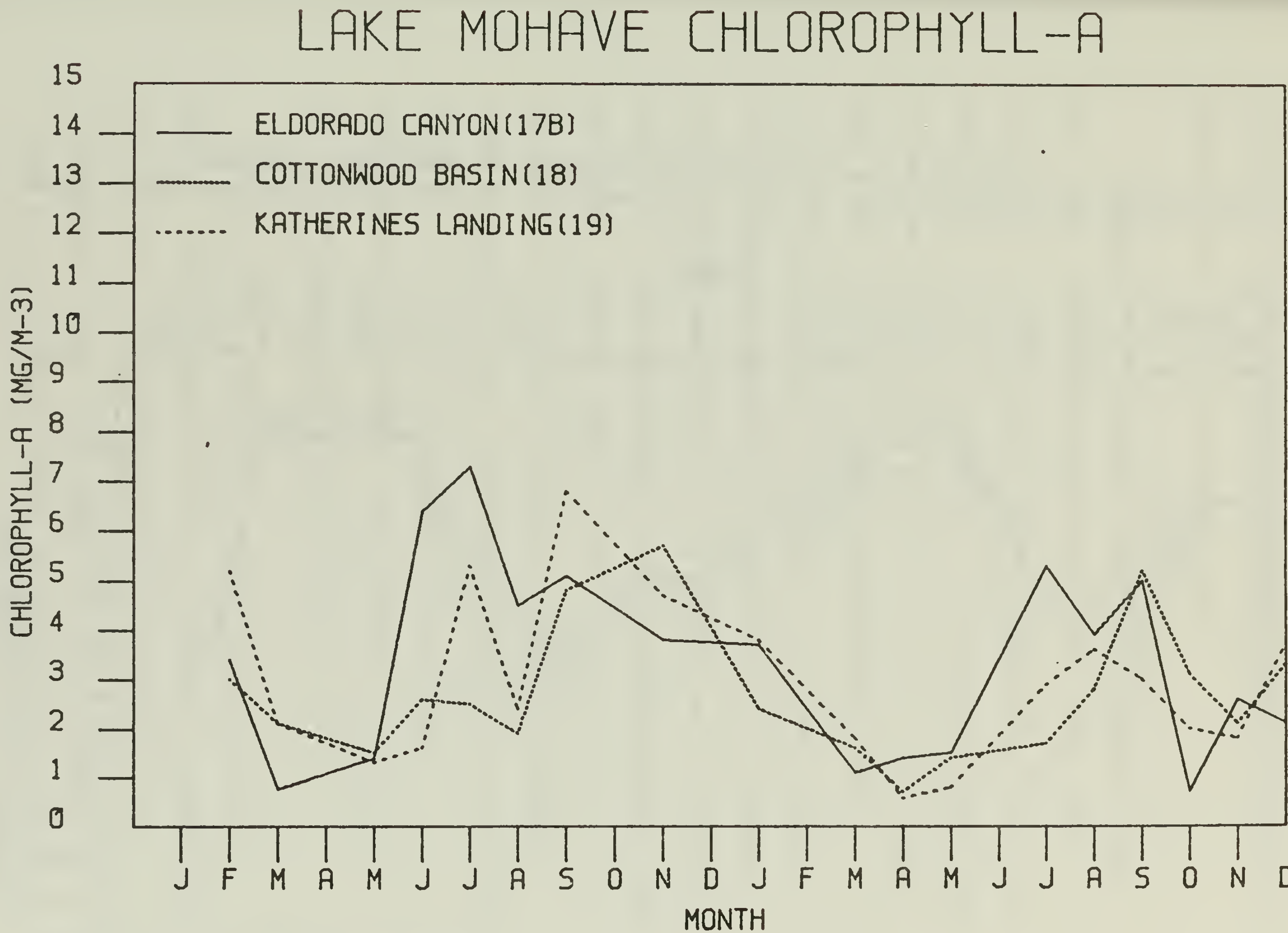

Figure 4.43 Monthly chlorophyll-a concentrations in 0-5m integrated depths at select locations in Lake Mohave during 1981 and 1982.

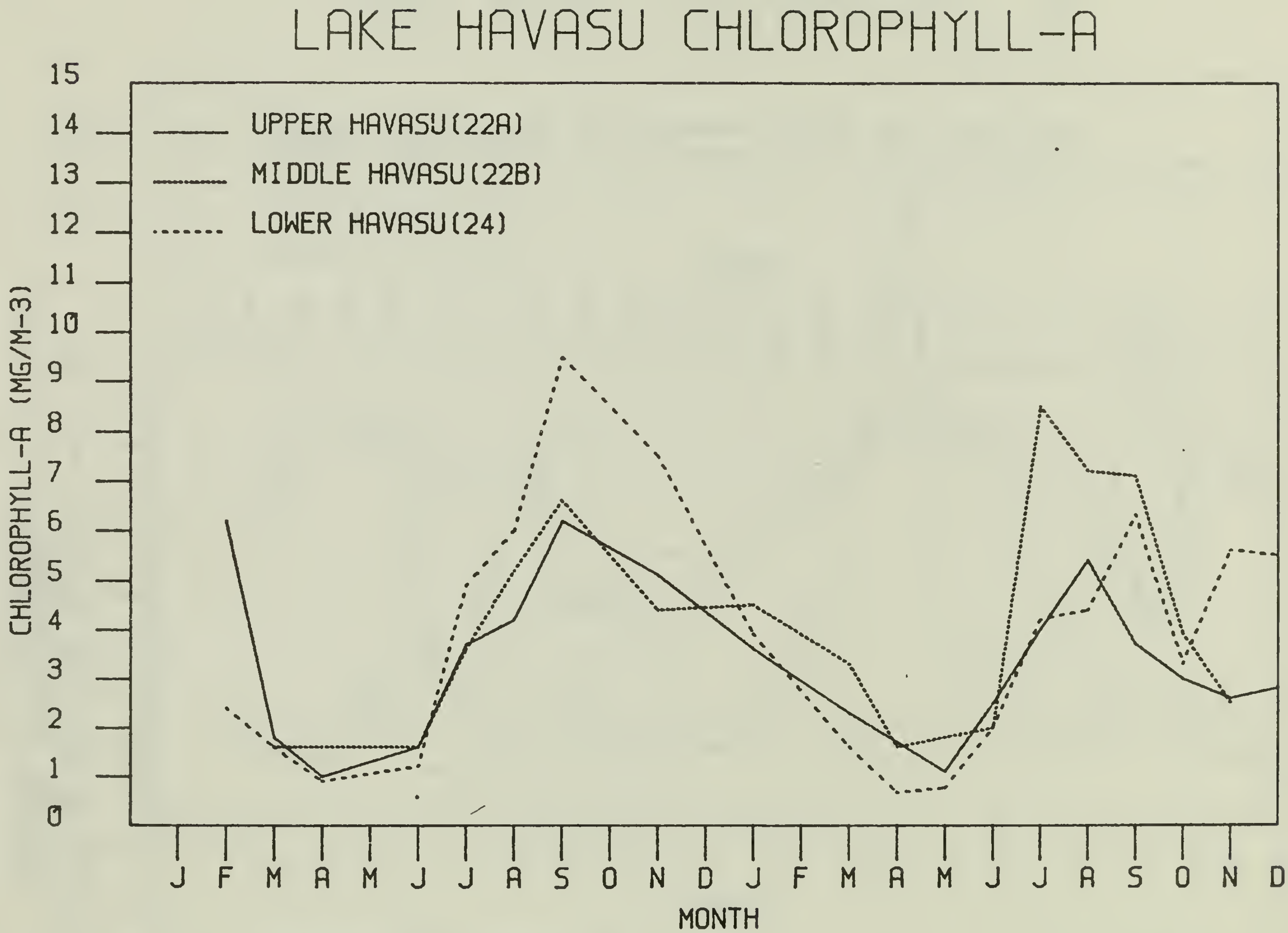

Figure 4.44 Monthly chlorophyll-a concentrations in 0-5m integrated depths at select locations in Lake Havasu during 1981 and 1982.

Chlorophyll-a concentrations were similar at all stations in Lake Mohave, although concentrations at Eldorado Canyon were usually the highest in the reservoir. In Lake Havasu, chlorophyll-a concentrations were usually highest at lower Havasu (24) and middle Havasu (22b).

Phytoplankton productivity was measured throughout Lake Mead in 1981 and in Boulder Basin during 1982 (Fig. 4.45). Productivity was also measured in Lake Mohave (Fig. 4.46) and Lake Havasu (Fig. 4.47) during 1981. Phytoplankton productivity in Lake Mead was low at all stations during the winter months (Fig. 4.45). Productivity usually averaged about 300 mg c/m^2/day during the winter. Productivity increased sharply during spring and remained high through August. The highest productivity in main basin areas during 1981 was in Boulder Basin (Fig. 4.45). Productivity in Boulder Basin ranged to 1800 mg c/m^2/day during the summer of 1981. Productivity elsewhere in the reservoir ranged from 500-700 mg c/m^2/day during the summer months. Productivity decreased at all stations during the fall and averaged about 300 mg c/m^2/day. Productivity in Boulder Basin was much lower in 1982 than in 1981 and averaged about 400 mg c/m^2/day for the year.

Phytoplankton productivity in Lake Mohave during 1981 followed a seasonal pattern similar to Lake Mead. Productivity was 300-500 mg c/m^2/day during winter, but increased to 2000-3000 mg c/m^2/day during summer and then decreased back to about 500 mg c/m^2/day by early summer and fall.

The pattern was somewhat different in Lake Havasu in that

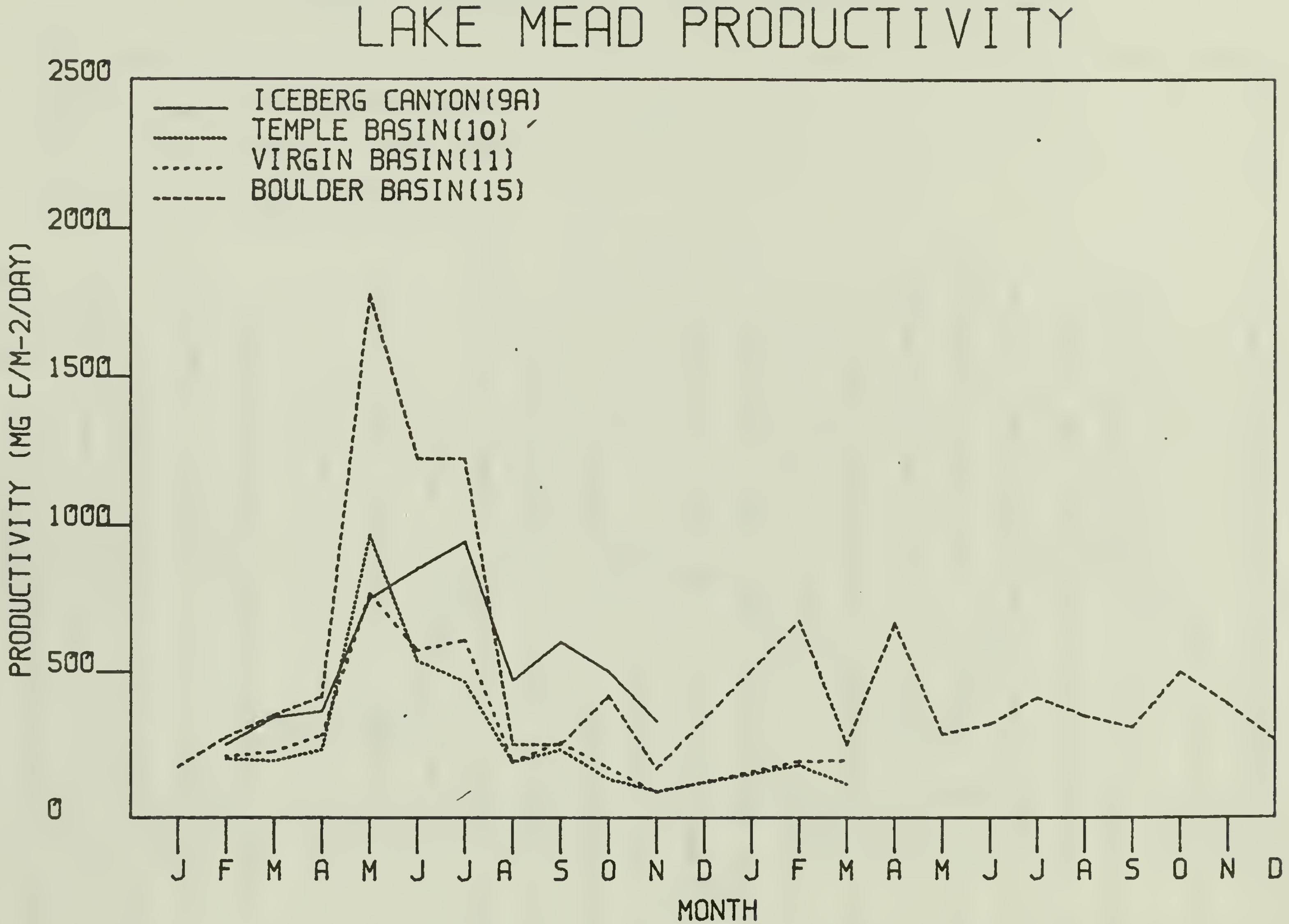

Figure 4.45 Monthly phytoplankton productivity at select locations in Lake Mead during 1931 and 1982.

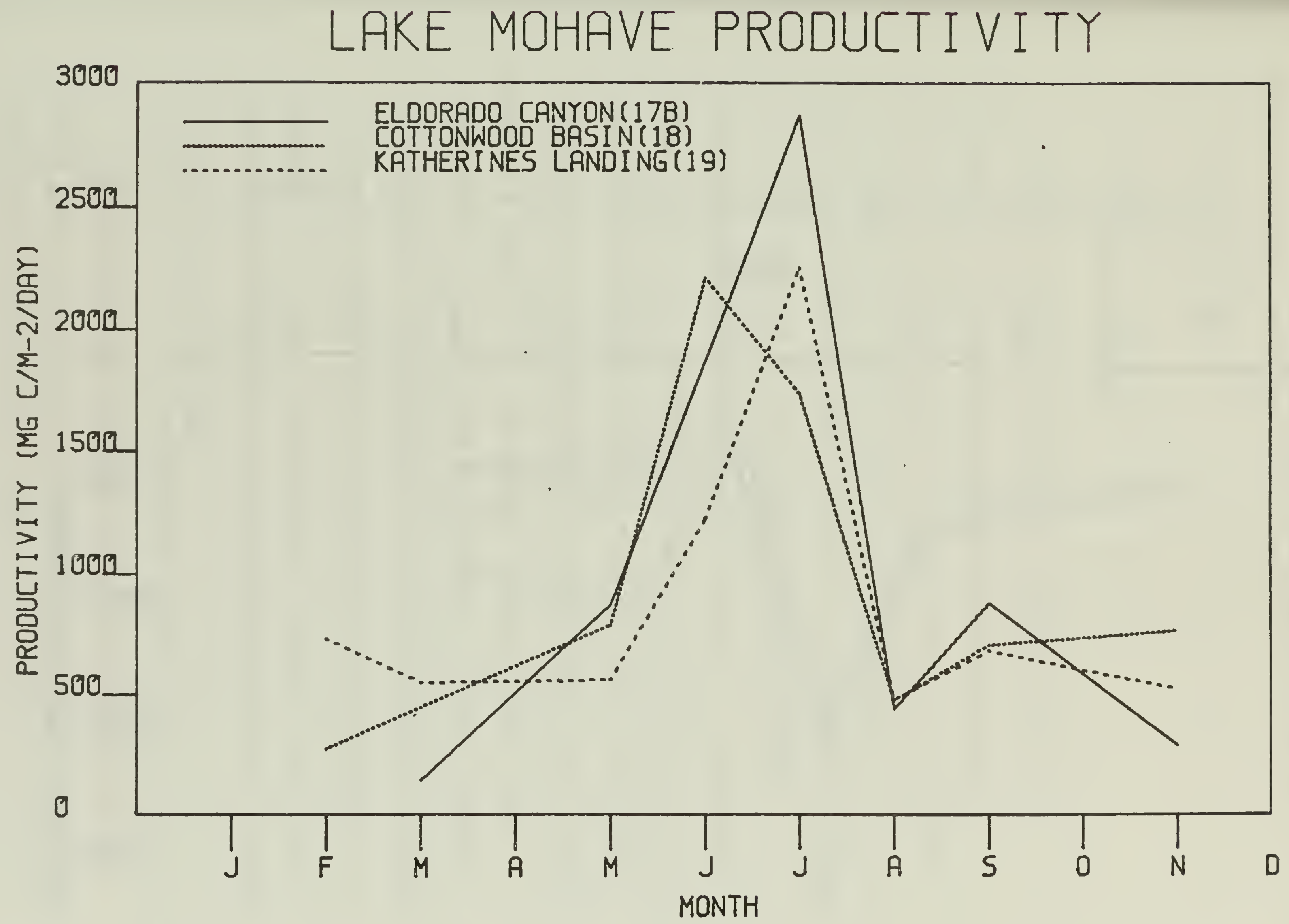

Figure 4.46 Monthly phytoplankton productivity in Lake Mohave during 1981.

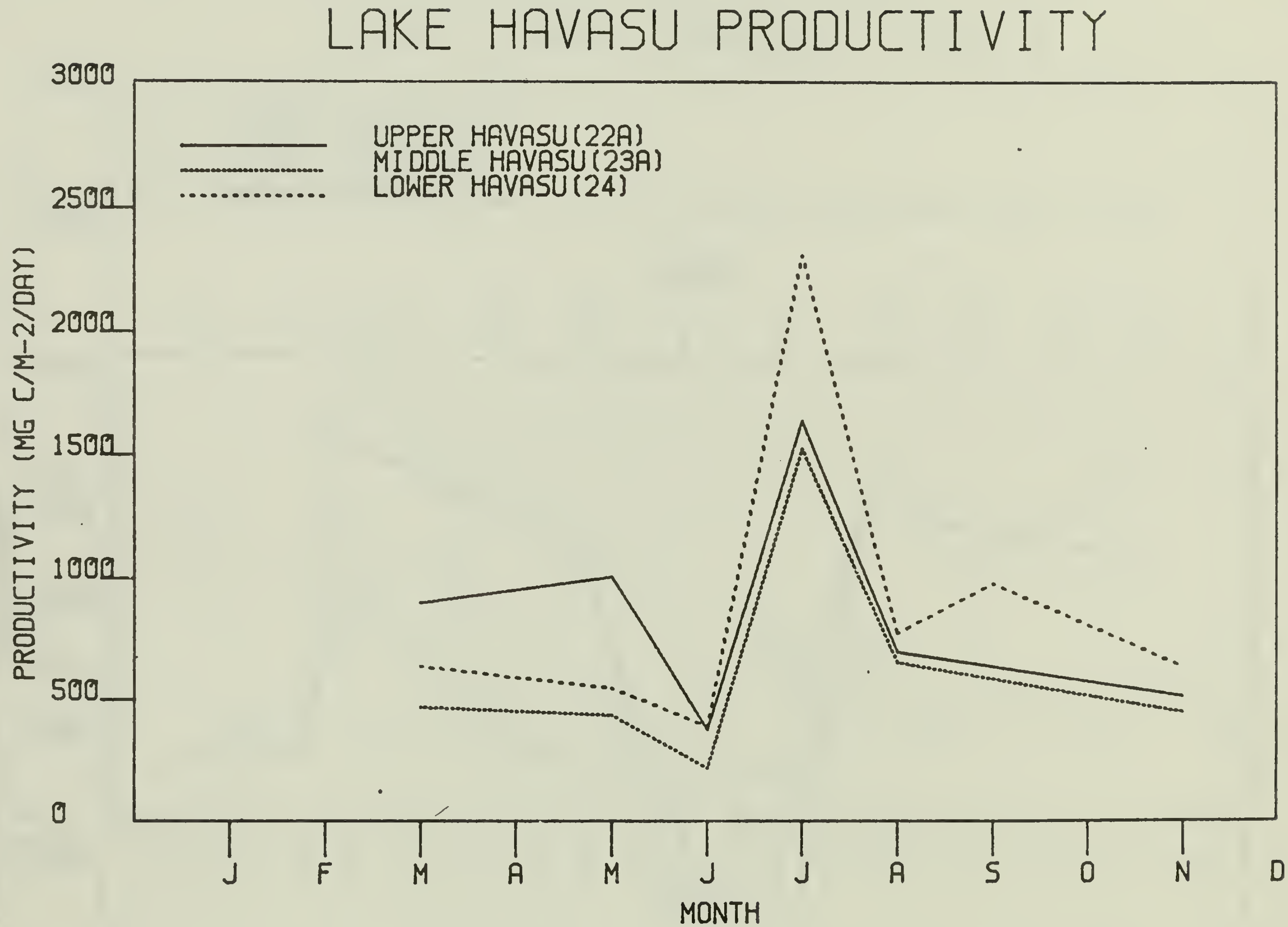

Figure 4.47 Monthly phytoplankton productivity in Lake Havasu during 1981.

productivity decreased to its lowest level in June at all stations (Fig. 4.47). Productivity then increased sharply during July and decreased again in August. Productivity was usually highest at the lower Havasu (24) station.

5.0 DISCUSSION

5.1 General Limnology

The most prevalent limnological characteristic of the Colorado River reservoirs during 1981 and 1982 was the low phosphorus concentrations that existed in most of the system. The area-weighted, annual average total phosphorus concentrations for Lake Powell and Lake Mead were only .008 mg P/l in 1981 and .010 mg P/l in 1982 (Table 5.1). Total phosphorus concentrations averaged .012 mg P/l in Lake Mohave during both years of the study. In Lake Havasu, total phosphorus concentrations averaged .012 mg P/l in 1981 and .017 mg P/l in 1982 (Table 5.1). The Hite station in Lake Powell, the inner and middle Las Vegas Bay in Lake Mead, Eldorado Canyon in Lake Mohave and lower Lake Havasu stations were the only reservoir locations where total phosphorus concentrations usually exceeded .015 mg P/l. Orthophosphorus concentrations were extremely low throughout the system. Orthophosphorus averaged .002-.003 mg P/l at most reservoir locations, and concentrations rarely exceeded .005 mg P/l during the study.

The low phosphorus concentrations in the reservoirs were largely due to the unique nature of phosphorus inputs. A large percentage of the phosphorus inputs to the reservoirs from the

Table 5.1 Summary of nutrients and productivity in reservoirs on the Colorado River (based on area weighted annual averages).

		RESERVOIR			
PARAMETER	YEAR	LAKE POWELL	LAKE MEAD	LAKE MOHAVE	LAKE HAVASU
Total Phosphorus (mg/l)	1981	.008	.008	.012	.012
	1982	.010	.010	.012	.017
Total Nitrogen (mg/l)	1981	.420	.364	.335	.317
	1982	.454	.380	.381	.349
Total Nitrogen/ Total Phosphorus Ratio	1981	52.5	45.5	27.9	26.4
	1982	45.4	38.0	31.8	20.5
Phytoplankton Productivity (mg c/m^2/day)	1981	-	480	939	780
Phytoplankton Productivity (mg c/m^3/day)	1981	-	24	47	68
Chlorophyll-a (µg/l)	1981	2.3	1.5	3.3	3.4
	1982	2.1	1.5	2.3	3.3

tributaries and main stem was bound to suspended sediments (Gloss et al. 1981; Mayer and Gloss 1980; Evans and Paulson 1983). This was especially evident in inputs to Lake Powell. Total phosphorus loadings to that reservoir were 4143 t/yr. in 1981 and 9981 t/yr. in 1982. Of these loadings, only about 10% was biologically-available phosphorus and 1% was orthophosphorus. Over 90% of the total and biologically-available phosphorus inputs to Lake Powell were sedimented (retained) in the reservoir. Most of the sedimentation seemed to occur upstream of Hall's Crossing and in the San Juan Arm. Consequently, total and orthophosphorus concentrations were extremly low in the middle and lower reaches of the reservoir.

Phosphorus loss rates from Glen Canyon Dam also were low during the study. Discharges from the dam resulted in annual losses of about 75 t/yr. of total phosphorus and about 40 t/yr. of orthophosphorus. Tributary inflows in Grand Canyon, especially the Little Colorado River, provided substantial amounts of total phosphorus to the Colorado River between Glen Canyon Dam and Lake Mead. However, orthophosphorus loads did not increase appreciably in Grand Canyon, indicating that most of the phosphorus inputs also were bound to suspended sediments. The Colorado River inflow to Lake Mead only resulted in a slight increase in total and orthophosphorus concentrations in the Upper Arm of the reservoir. Total and orthophosphorus concentrations in the Virgin Basin and Overton Arm were extremely low throughout the study. The Virgin River was a significant source of total phosphorus to Lake Mead, but again,

most of this was bound to suspended sediment. The Virgin River thus had no appreciable influence on phosphorus concentrations in the Overton Arm.

Las Vegas Wash was the only inflow that provided a fairly constant input of biologically-available phosphorus and orthophosphorus to the Colorado River. Orthophosphorus loading from Las Vegas Wash to Lake Mead exceeded that from the Colorado River and other tributaries in 1981. Las Vegas Wash provided about 90% of the orthophosphorus inputs to Lake Mead in 1982, even though loading was reduced substantially after July, 1981 due to phosphorus removal at the City of Las Vegas and Clark County Sewage Treatment Plants. The phosphorus inputs from Las Vegas Wash consistently elevated phosphorus concentrations in the inner and middle Las Vegas Bay areas of Lake Mead (Paulson and Baker 1983). The Las Vegas Wash inflow also resulted in a slight increase in phosphorus concentrations in Boulder Basin and the Hoover Dam discharge.

Orthophosphorus losses from Hoover Dam exceeded or nearly equalled inputs from the Colorado River in Grand Canyon as a result of loading from Las Vegas Wash. Although significant percentages of total and bio-available phosphorus inputs were retained in Lake Mead, large quantities were still discharged from Hoover Dam. This increased the phosphorus concentrations in Lake Mohave, particularly in the Eldorado Canyon area. Total phosphorus loss rates at Davis Dam were similar to those at Hoover Dam indicating that very little phosphorus was retained in Lake Mohave. Total phosphorus loads increased slightly

between Davis Dam and Parker Dam. This most likely was caused by phosphorus inputs from the Bill Williams River which enters Lake Havasu near Parker Dam. It is also possible that some phosphorus pick-ups occurred in the reach between Davis Dam and upper Lake Havasu.

Total nitrogen concentrations in the reservoirs decreased downstream from the headwaters of Lake Powell. Total nitrogen concentrations in Lake Powell averaged .420 mg N/l in 1981 and .454 mg N/l in 1982 (Table 5.1). Total nitrogen concentrations in Lake Mead averaged .364 mg N/l in 1981 and .380 mg N/l in 1982. In 1981, total nitrogen concentrations decreased to an average of .335 mg N/l in Lake Mohave and .317 mg N/l in Lake Havasu. Total nitrogen concentrations in Lake Mohave were nearly identical to those in Lake Mead during 1982. Total nitrogen concentrations averaged .349 mg N/l in 1982. The general downstream decrease in total nitrogen concentrations was caused by nitrogen retention in each reservoir and by the lack of significant nitrogen inputs from downstream tributaries. Las Vegas Wash contributed about 1000 t/yr. of total nitrogen to Lake Mead, but this was not sufficient to replace that retained in the reservoir. The other tributaries were minimal sources of total nitrogen to the Colorado River.

The reservoirs were all phosphorus limited on the basis of area-weighted, annual average total nitrogen/total phosphorus (TN/TP) ratios. TN/TP ratios for Lake Powell averaged 52.5 in 1981 and 45.4 in 1982 (Table 5.1). TN/TP ratios were also high in Lake Mead and averaged 45.5 in 1981 and 38.0 in 1982. TN/TP

ratios decreased to an average of about 30 in Lake Mohave and 20-25 in Lake Havasu. The decrease in TN/TP ratios in those two reservoirs reflects the slight increase in phosphorus and decrease in nitrogen in downstream areas of the river. However, the average annual TN/TP ratios never approached levels (10) where nitrogen would be considered limiting.

Phytoplankton productivity was not measured in Lake Powell during our study, but measurements were made in Lake Mead, Lake Mohave and Lake Havasu during 1981. Area-weighted, average daily phytoplankton productivity was 480 mg c/m^2/day in Lake Mead. This increased to 939 mg c/m^2/day in Lake Mohave and then decreased to 780 mg c/m^2/day in Lake Havasu. The decrease in Lake Havasu was due to shallower depths in that reservoir. Productivity per unit volume, which compensates for depth differences, averaged 24 mg c/m^3/day in Lake Mead, 47 mg c/m^3/day in Lake Mohave and 68 mg c/m^3/day in Lake Havasu. Area-weighted average chlorophyll-a concentrations followed a similar pattern and averaged about 1.5 µg/l in Lake Mead, about 3.0 µg/l in Lake Mohave and a little over 3.0 µg/l in Lake Havasu (Table 5.1). Chlorophyll-a concentrations were slightly higher in Lake Powell than in Lake Mead and averaged about 2.0 µg/l (Table 5.1). This was due to the higher productivity in the San Juan Arm and headwaters of Lake Powell.

Phosphorus loading appears to be the principal factor regulating overall productivity in the reservoirs. However, hydrodynamics plays an important role in regulating the availability of phosphorus within each reservoir. The Colorado

River inflow to Lake Powell enters the reservoir as a turbid overflow during the spring (April-June) (Merritt and Johnson 1977; Gloss et al. 1980). Runoff into Lake Powell in 1981 was very low, and the effects of the overflow were not evident much below Hite. However, with the high runoff in 1982, the overflow extended downstream of Hall's Crossing by June and may have reached Padre Bay and Wahweap by late summer. The spring overflow resulted in an increase in phosphorus concentrations in the epilimnion of the upstream areas, even though a large percentage of the phosphorus was bound to suspended sediments. The overflow seemed to be an important factor in providing the phosphorus necessary to stimulate a productivity pulse in Lake Powell during late spring and early summer.

The Colorado River inflow to Lake Mead generally entered as an interflow or underflow. Temperatures in the inflow were cold due to withdrawls from the hypolimnion of Lake Powell. River temperatures increased somewhat in Grand Canyon, but seldom exceeded surface temperatures in Lake Mead. The river entered Lake Mead as a interflow or underflow during most of the study. Discharges from Glen Canyon Dam were highest during late summer, fall or winter. About 70% of the annual inflows occurred during periods when the river formed a deep interflow or underflow in the reservoir. This greatly decreased mixing and reduced the availability of nutrients to the epilimnion. The hydrodynamic patterns, coupled with low phosphorus loading from the Colorado River were major factors limiting productivity in the upper basin of Lake Mead.

The Las Vegas Wash inflow also formed a density current in Las Vegas Bay of Lake Mead (Paulson et al. 1980; Baker and Paulson 1980). The inflow formed an underflow in the bay during winter, a brief overflow during spring and an interflow during summer and fall (Paulson et al. 1980). Mixing at the head of the bay resulted in higher epilimnetic nutrient concentrations in the inner and middle Las Vegas Bay during spring and summer months. However, a large percentage of the Las Vegas Wash inflow entered the hypolimnion in Boulder Basin and was discharged at Hoover Dam. This largely was the origin of the higher phosphorus loading to the downstream reservoirs.

Discharges from Hoover Dam readily mixed with waters in Lake Mohave during winter when reservoir temperatures were slightly cooler or equal to river temperatures (Priscu et al. 1980; Paulson et al. 1980; Priscu et al. 1982). A brief overflow occurred during early spring, and the river formed an underflow in the reservoir during summer and fall (Paulson et al. 1980; Priscu et al. 1982). Discharges from Hoover Dam were high and reservoir levels were low during spring and summer months. This resulted in considerable mixing in the upper end of the reservoir, particularly in Eldorado Canyon at the convergence of river and reservoir waters (Paulson et al. 1980). A large percentage of the phosphorus inputs from Hoover Dam were in the form of orthophosphorus or bio-available phosphorus. This combined with the higher mixing resulted in high productivity in the upper end of Lake Mohave. Thermal stratification was extremely sharp in the main basin areas of Lake Mohave during summer. This reduced mixing and nutrient availability to the

epilimnion. In the lower end of Lake Mohave, turbulence caused by discharge cycles from Davis Dam and/or upwelling of the underflow from Hoover Dam caused more mixing just upstream from the dam (Paulson et al. 1980). This, in turn, seemed to cause some increase in the nutrient concentrations and productivity in that area.

Discharge temperatures from Davis Dam averaged about 16-17°C during the study. Discharges were high during the spring and summer months. The river enters Lake Havasu below Topock Gorge where depths are shallow as a result of the extensive sand bars in the area. The reservoir did not thermally stratify, and the inflow readily mixed with waters in Lake Havasu. There was no evidence of significant density currents in Lake Havasu. The reservoir seemed to mix to the bottom in all areas except at the dam. This greatly increased nutrient availability and was an important factor in causing the higher productivity in Lake Havasu.

The trophic state of reservoirs on the Colorado River was low. Lake Powell and Lake Mead were oligotrophic on the basis of area-weighted, average chlorophyll-a concentrations. Lake Mohave and Lake Havasu were mesotrophic based on that trophic state criterion. The oligotrophic/mesotrophic nature of the reservoirs is due to low phosphorus concentrations that persist in most of the system. Most of the phosphorus inputs are associated with suspended sediments. Sedimentation in the headwaters of Lake Powell effectively retains most of the phosphorus that historically flowed downstream. Suspended sediments and

phosphorus inputs from Grand Canyon rapidly sediment in the upper end of Lake Mead. The Virgin River and Muddy River inflows to Lake Mead are minor sources of phosphorus to the system. Las Vegas Wash is the principal tributary input of phosphorus to the river. The majority of this input is in the form of orthophosphorus or bio-available phosphorus.

The Las Vegas Wash inflow significantly elevates phosphorus concentrations in the inner and middle Las Vegas Bay, and it causes some increase in concentrations in Boulder Basin and the Hoover Dam discharge. Phosphorus loading to Lake Mohave increases as a result of inputs from Las Vegas Wash. Phosphorus retention in Lake Mohave is low due to rapid flushing of the reservoir. Most of the phosphorus discharged from Hoover Dam is thus routed through Lake Mohave into Lake Havasu. Additional phosphorus inputs to Lake Havasu are derived from the Bill Williams River and possibly from pick-ups in the reach between Davis Dam and upper Lake Havasu.

The Las Vegas Wash inflow seems to be a major reason for the higher trophic state in the downstream reservoirs. The decrease in phosphorus loading that has occurred in Las Vegas Wash as a result of phosphorus removal at the City of Las Vegas and Clark County Sewage Treatment Plants can be expected to decrease productivity in Lake Mohave and possibly Lake Havasu. The slight decrease that occurred in chlorophyll-a concentrations in Lake Mohave during 1982 probably reflects the reduction in phosphorus loading. Productivity in the Boulder Basin area of Lake Mead has undergone a steady decline since the

late 1970's when phosphorus loading from Las Vegas Wash began to decrease (Paulson and Baker 1983). This appears to be a major factor responsible for the fisheries problems recently experienced in the reservoir. Similar reductions in the productivity of Lake Mohave will probably also result in a decline in fish production. This should be carefully evaluated in ongoing reviews of current wastewater treatment practices at the City of Las Vegas and Clark County Sewage Treatment Plants. A relaxation of the phosphorus standards at Las Vegas Wash may be warranted considering the low productivity in the river system.

5.2 Principal Impacts of Hydroelectric Facilities on Water Quality

The hydroelectric dams on the Colorado River affect water quality in several ways. First, the large reservoirs, Lake Powell and Lake Mead, trap a large percentage of the inflowing nutrients. About 98% of the total phosphorus and 46% of the total nitrogen inputs from the Colorado and San Juan Rivers were retained in Lake Powell. Similarly, about 90% of the total phosphorus and 43% of the total nitrogen inputs from the Colorado, Virgin and Muddy Rivers and Las Vegas Wash were retained in Lake Mead. The two reservoirs collectively removed an average of 26.9 t N/day and 22.0 t P/day from the river and tributaries during our two year study. The extremely high removal of phosphorus was due to sedimentation of phosphorus bound to clays and silt. Minimal amounts of phosphorus were retained in Lake Mohave, and phosphorus losses seemed to exceed

inputs in Lake Havasu. Some nitrogen was retained in each reservoir, but rates were much lower than in Lake Powell and Lake Mead.

The dams also influence water quality by altering natural variability in some of the physical and chemical characteristics of the river. Extreme variation in discharge rates, temperatures, salinity and nutrient concentrations was common in the Colorado River inflow to Lake Powell. During our study, discharges ranged from .262-2.123 million acre-feet. Temperatures varied from 5.3-27.6°C; conductivity from 425-1560 µmhos/cm; total phosphorus from .019-4.45 mg P/l and total nitrogen from .528-3.5 mg N/l (Table 5.2).

The current operations of Glen Canyon Dam and Hoover Dam greatly reduce this variability. In part, this is due to the stabilizing effects that the dams have on seasonal and annual variations in discharges. However, an equally important factor is the depth of discharge from the dams. Glen Canyon and Hoover Dams are both operated from a hypolimnion discharge. Seasonal events have a minimal influence on the hypolimnia of the large reservoirs and conditions remain relatively stable. Consequently, variability in most factors is greatly reduced in the outflows.

This was especially evident in temperatures which only varied from 7.0-12.8°C in the Glen Canyon Dam outflow and 11.8-13.4°C in the Hoover Dam outflow (Table 5.2). Variability of other factors in the outflows was also less than in the unregulated inflows.

Table 5.2. Ranges of select physical and chemical characteristics in the Colorado River during 1981 and 1982.

	Parameter				
Location	Discharge (MAF)	Temperature (°C)	Conductivity (µmhos/cm)	Total Phosphorus (mg/1)	Total Nitrogen (mg/1)
Colorado River Inflow	.262-2.123	5.3-27.6	425-1560	.019-4.45	.578-3.568
Glen Canyon Dam	.423- .959	7.0-12.8	800-1150	.004- .020	.396- .731
Hoover Dam	.379-1.042	11.8-13.4	1050-1250	.003- .018	.369- .656
Davis Dam	.313-1.035	9.5-20.0	1050-1300	.005- .040	.317- .682
Parker Dam	.230- .928	9.5-27.0	1070-1300	.005- .018	.341- .402

Seasonal variability in temperatures was restored to the river downstream of Davis Dam. Although Davis Dam is operated from a deep-discharge, considerable mixing occurs in the Katherine's Landing area, just upstream of the dam (Paulson et al., 1980). The outflow thus represents a composite of epilimnetic and hypolimnetic waters. There was a definate seasonal temperature cycle in the outflow, but temperatures did not reach extremes of unregulated sections of the river. Temperatures ranged from 9.5-20.°C in the Davis Dam outflows during our study.

Parker Dam is operated with an epilimnion discharge. Temperatures in the outflow ranged from 9.5 -27.0°C and followed a seasonal pattern similar to that in unregulated sections of the river. Variability in other factors was similar to that below the other dams (Table 5.2).

The Bureau of Reclamation is currently planning several modifications in the operations of the dams. Perhaps most significant are the changes required in flood control operations now that the system has reached full capacity. Flood control releases will have to be made during fall and winter to accomodate spring runoff. Such changes in river operations will not adversely influence water quality. The system is severely limited by phosphorus, and this will hold down productivity regardless of the manner in which the dams are operated. However, higher releases from Lake Powell during winter and spring could be beneficial in Lake Mead since more nutrients would enter the reservoir when it is completely mixed. This

could stimulate slightly higher productivity in the main basin areas during spring and could help the fisheries.

The bureau is also planning to uprate the powerplants at Glen Canyon and Hoover dams. These modifications will result in higher peak daily discharges. Detailed environmental assessments have shown that such modifications to Hoover Dam will not significantly affect water quality (Paulson et al., 1980). Environmental studies are currently being conducted at Glen Canyon Dam. Based on our findings, it does not appear that modifications to that powerplant will appreciably alter water quality either. However, there are numerous potential impacts in Grand Canyon that warrant careful consideration and are currently under study by the bureau.

The bureau is also doing a feasibility study on the installation of a pump-storage unit at Spring Canyon, AZ in Lake Mead. The project site is located in a dry wash, just south of Virgin Canyon, west of Hualapi Wash and east of Greggs Hideout. The site is located between our sampling stations in Gregg Basin (9b) and Temple Bar (10).

The project will consist of a 394 ft. dam, a 218,000 acre-feet reservoir, an underground powerhouse and reversible pump-generator units (USBR data). The penstock-tailrace complex will consist of four tunnels. The inlet-outlet works will be 38 ft. in diameter and will be installed in the canyon walls at 1069 ft. elevation. This is 155 ft. below the Hoover Dam spillway crest of 1205 ft.

Under normal operations, the facility will pump for up to 12 hours/day. Pumping will be done during off-peak hours at night and on weekends. Generation will occur during peak demand periods in the week. Flows as high as 79,000 cfs could occur when the plant is operating at full capacity. Flow rates as high as 3 ft/sec will occur at the inlet-outlet portals.

It is difficult to assess the impacts of this project on water quality because the operating criteria have not been firmly established. Nonetheless, it is possible to make some general remarks. Water will be drawn from, and returned to, the hypolimnion of Virgin Canyon. It is expected that water levels could change by as much as a foot in the vicinity of the project site during a pump/generate cycle. Hypolimnetic volumes are perhaps sufficient at current lake elevations to accomodate the pumping requirements. However, it is likely that repeated, daily operations will eventually disrupt thermal stratification in the canyon and possibly elsewhere in the basin.

The temperature isotherms in the upper hypolimnion will be pulled down toward the inlet/outlet portals, and the cold hypolimnion water will be drawn from the reservoir. On the generating cycle, water will be forced back into the hypolimnion initially causing high turbulence near the inlet/outlet portals. As the water collides with the hypolimnion water, an upwelling could occur forcing cold water toward the surface. This could be especially pronounced if water temperatures increase during impoundment in the Spring Canyon Reservoir. This will elevate the epilimnion and metalimnion and possibly disrupt thermal

stratification near the inlet/outlet portals. The generating-water will eventually reach a velocity sufficient to overcome the down-lake flow of the hypolimnion. When this occurs, the hypolimnion will be set in reverse motion and pushed back into Virgin Canyon. The generating water could then collide with the canyon walls or be forced back into Gregg Basin. After the generating cycle, the upwellings will dissipate and the isotherms will start to return to their normal position. However, the temperature of water will be slightly colder and thermal stratification less stable than prior to the initial pumping cycle.

The isotherms will be pulled down even further on the second and successive pumping cycles because the temperature of overlying water will be colder, and less dense, than on the initial power cycle. Thus, more replacement water will be drawm from overlying strata. Upwelling will also occur at each successive generating cycle. The continual turbulence generated on the pumping and generating cycles will, at the least, alter temperature and currents in Virgin Canyon and at the worst, disrupt thermal stratification in these areas and possibly in parts of Gregg and Virgin Basins. Although the volume of pumped-water is small by comparison to the volume in the basins, it is the cumulative, rather than instantaneous, effects of repeated pumping that will eventually alter limnological conditions.

The local effects of pumping will be greatest in Virgin Canyon, but, after prolonged pump/generate operation during the

summer, the temperature and current patterns are likely to be disrupted up and down-lake.

The hypolimentic waters tend to be slightly higher in nutrients than in the epilimnion. The mixing created by repeated pump/generate cycles could increase nutrient availability and stimulate higher productivity in the vicinity of the project site. Turbidity might also increase from sediment resuspesion. However, these changes probably will not be perceptible without the aid of limnological monitoring equipment.

The project could have numerous other impacts that cannot be addressed in this study. It could alter the circulation patterns in the upper basin. Evaporation rates, salinity and nutrients are all influenced by these circulation patterns. Plankton, fish and other aquatic life could be entrained in the inlet works during pumping operations. A detailed environmental assessment will be required to adequately evaluate the ecological impacts of this project.

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Appendix Table A. Monthly or average monthly total phosphorus concentrations in surface composite samples for reservoir inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay, 14a(BC2) is 0-2.5 m integrated depth.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	.009	--	.007	--	.007
4	.200	.011	.010	.011	.020	.003
5	.119	.021	.013	.014	--	.004
6	.294	.034	.020	.016	.022	.010
7	.179	.015	.009	.011	.008	.007
8	.195	.020	.007	.004	.003	.003
9	4.455	.021	.010	.006	.004	.005
10	1.250	.012	.012	.004	.005	.004
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	.956	.018	.012	.009	.010	.005

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	.057	--	--	.007	.009	.007	.004	.020
4	.084	.019	--	.005	.006	.008	.008	.010
5	.146	.018	--	.004	.004	.005	.003	.008
6	.103	.026	--	.007	.006	.008	.006	.006
7	.090	.016	.040	.015	.018	.009	.008	.010
8	1.251	.009	--	.003	.013	.004	.003	.005
9	.100	.008	..023	.003	.006	.003	.003	.005
10	.223	.011	--	.005	.004	.004	.005	.006
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	.257	.015	.032	.006	.008	.006	.005	.009

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	.267	--	--	--
2	.034	.024	.018	.012	.013	.009	.020	--	.010	.007	--
3	.013	.029	.006	.010	.003	.008	.004	.083	.007	.006	--
4	.015	.006	.006	.006	.008	.004	.004	.200	.006	.004	.003
5	.012	.004	.010	.004	.004	.004	.004	--	.006	.018	.007
6	.011	.006	.005	.004	.006	.004	.005	.567	.009	.006	.004
7	.072	.016	.008	.014	.008	.006	.007	.367	.038	.013	.007
8	.184	.072	.007	.035	.015	.003	.003	.132	.012	.005	.005
9	.062	.013	.011	.012	.010	.005	.004	.165	.011	.009	.007
10	.120	.013	.026	.016	.008	.023	.005	.193	.013	.008	.005
11	.036	.008	.009	.009	.004	.003	.004	.124	.006	.004	.003
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	.056	.019	.011	.012	.008	.007	.006	.233	.012	.008	.005

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.274	--
2	--	.007
3	.336	.013
4	.474	.010
5	--	.018
6	.054	.007
7	42.250	.047
8	3.925	.018
9	.797	.014
10	.966	.010
11	.182	.004
12	--	--
AVG.	5.473	.015

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	2.005	.039	.031	--	.019	.019	.015
2	2.190	.037	.020	--	.031	.018	.018
3	2.675	.048	--	--	.012	.013	.018
4	2.970	.200	--	--	.011	.009	.008
5	2.637	.225	.120	.056	.045	.008	.007
6	1.351	.212	.120	.039	.015	.006	.008
7	.486	.106	.075	.030	.018	.009	.055
8	.425	.117	.047	.026	.046	.006	.009
9	.339	.053	.068	.020	.028	.007	.003
10	.309	.032	.022	.017	.011	.016	.012
11	.253	.013	.012	.011	.062	.005	.027
12	.275	.013	.012	.006	.008	--	--
AVG.	1.320	.091	.053	.026	.025	.010	.016

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	.016	.021	.025	.019	.024	.040
3	.010	.012	.012	.010	.008	.006	.010
4	--	--	--	--	--	--	--
5	.017	.016	.014	.008	.010	.005	.005
6	.014	.014	.032	.009	.009	.011	.009
7	.010	.011	.017	.011	.009	.011	.012
8	.013	.011	.015	.009	.009	.011	.010
9	.014	.013	.017	.009	.012	.011	.010
10	--	--	--	--	--	--	--
11	.010	.013	.013	.013	.011	.010	.012
12	--	--	--	--	--	--	--
AVG.	.013	.013	.018	.012	.011	.011	.013

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	.024	.028	--	.019	--	.018	.036
3	.014	.010	.010	.011	.008	.008	.007	.019
4	--	--	--	--	--	--	--	--
5	.010	.009	.007	.012	.005	.004	.003	.005
6	.013	.009	.010	.005	.006	.005	.010	.035
7	.017	.012	.013	.017	.009	.011	.009	.015
8	.012	.013	.014	.013	.012	.011	.014	.018
9	.015	.012	.015	.014	.010	.010	.016	.027
10	--	--	--	--	--	--	--	--
11	.021	.016	.013	.015	.013	.039	.018	.020
12	--	--	--	--	--	--	--	--
AVG.	.015	.013	.014	.012	.010	.013	.012	.022

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	.019	.006	.006	.006	.004	.006
2	.580	.010	.007	.010	.010	.007
3	.596	.008	.005	.008	.006	.006
4	.268	.011	.005	.007	.007	.005
5	.325	.028	.019	.055	.004	.006
6	.391	.040	.020	.021	.014	.013
7	.099	.023	.009	.009	.007	.006
8	1.695	.025	.019	.015	.019	.014
9	1.409	.018	.011	.007	.008	.008
10	--	.012	.010	.009	.006	.010
11	.030	.013	.009	.011	.014	.005
12	--	--	--	--	--	--
AVG.	.541	.018	.011	.014	.009	.008

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	.005	.035	.005	.004	.004	.003	.006
2	--	.007	.040	.009	.008	.006	.005	.009
3	--	.012	.238	.005	.006	.006	.005	.008
4	.240	.009	.022	.006	.006	.006	.006	.010
5	--	.007	.027	.007	.004	.004	.010	.007
6	--	.011	,029	.007	.006	.008	.006	.006
7	.065	.010	.018	.010	.004	.005	.004	.007
8	4.448	.010	.017	.006	.024	.023	.046	.007
9	2.165	.016	.023	.008	.006	.006	.006	.008
10	.116	.010	.017	.008	.006	.009	.008	.004
11	--	--	--	.005	.008	.004	.006	.004
12	--	--	--	--	--	--	--	--
AVG.	1.407	.010	.047	.007	.007	.007	.010	.007

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	.013	.010	.006	.010	.006	.006	.008	.213	.011	.003	.006
2	.030	.010	.009	.006	.005	.005	.004	.128	.005	.002	.004
3	.096	.014	.011	.015	.008	.010	.004	.235	.009	.006	.003
4	.043	.015	.014	.014	.008	.007	.011	.223	.009	.008	.007
5	.076	.013	.012	.014	.008	.005	.006	.164	.014	.006	.006
6	.013	.008	.008	.009	.008	.007	.005	.223	.008	.005	.009
7	.027	.007	.011	.008	.010	.007	.004	.256	.008	.005	.003
8	.462	.009	.006	.005	.003	.004	--	.318	.009	.003	.004
9	.151	.013	.013	.016	.014	.011	.013	.210	.013	.009	.007
10	.218	.010	.012	.007	.007	.007	.005	.149	.009	.007	.002
11	.029	.008	.007	.007	.008	.006	.005	--	.007	.014	.006
12	.014	.007	.011	.009	.008	.005	.005	.198	.006	.006	.013
AVG.	.098	.010	.010	.010	.008	.007	.006	.211	.009	.007	.007

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.162	.007
2	.142	.005
3	1.081	.022
4	.330	.015
5	.151	.016
6	.024	.010
7	.012	.008
8	2.299	.014
9	.601	.018
10	.112	.007
11	--	.007
12	.450	.010
AVG.	.488	.012

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	.322	.010	.014	.020	.006	.008	.006
2	2.608	.017	.014	.012	.008	.009	.014
3	.873	.041	.019	.011	.010	.023	.012
4	.530	.056	.035	.014	.010	.012	.016
5	.747	.046	.037	.028	.017	.007	.012
6	.997	.074	.034	.011	.009	.009	.007
7	.907	.068	.053	.021	.016	.009	.007
8	.922	.104	.080	.051	.024	.008	.003
9	1.045	.070	.050	.021	.019	.006	.008
10	.812	.127	.025	.014	.012	.010	.007
11	.818	.018	.021	.015	.011	.004	.012
12	1.141	.022	.013	.007	.006	.006	.005
AVG.	.977	.054	.033	.019	.012	.009	.009

Appendix TAble A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	.014	.014	.015	.013	.010	.011	.014	.015
2	--	--	--	--	--	--	--	--
3	.015	.014	.017	.013	.012	.009	.017	.014
4	.011	.008	.006	.008	.005	.008	.006	.011
5	.018	.010	.010	.011	.016	.008	.010	.008
6	--	--	--	--	--	--	--	--
7	.010	.008	.013	.010	.008	.008	.009	.010
8	.248	.472	.017	.018	.014	.019	.011	.016
9	.018	.031	.013	.018	.012	.017	.012	.017
10	.011	.010	.012	.018	.014	.016	.016	.013
11	.009	.012	.016	.016	.018	.013	.014	.018
12	.011	.011	.013	.013	.013	.016	.014	.018
AVG.	.036	.059	.013	.014	.012	.012	.012	.014

Appendix Table A. (Cont.)

NUTRIENTS
TOTAL-PHOSPHORUS
(MG/L)
1982

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	.009	.008	.009	.007	.014	.011	.012
2	--	--	--	--	--	--	--
3	.008	.007	.008	.009	.011	.010	.011
4	.018	.010	.008	.013	.009	.015	.010
5	.010	.016	.016	.010	.009	.009	.015
6	.010	.021	.014	.008	.007	.012	.010
7	.003	.007	.008	.006	.005	.005	.011
8	.007	.210	.014	.009	.012	.014	.013
9	.006	.016	.014	.010	.009	.008	.009
10	.006	.008	.007	.010	.011	.008	.013
11	.017	.010	.008	.010	.009	.008	.011
12	.011	.007	.009	.017	.010	.011	.008
AVG.	.010	.029	.010	.010	.010	.010	.011

Appendix Table B. Monthly or average monthly Orthophosphorus concentrations in surface composite samples for reservoir inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay station 14a (BC2) is 0-2.5 m integrated depth.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	.002	--	.002	--	.002
4	.002	.001	.001	.001	.001	.002
5	.002	.001	.001	.001	--	.001
6	.008	.005	.003	.002	.004	.002
7	.005	.003	.003	.003	.003	.003
8	.002	.002	.001	.001	.001	.001
9	.004	.001	.003	.001	.002	.001
10	.007	.004	.002	.003	.003	.001
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	.004	.002	.002	.002	.002	.002

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	.018	--	--	.001	.001	.002	.002	.013
4	.015	.002	--	.001	.004	.004	.005	.010
5	.002	.001	--	.001	.001	.001	.001	.004
6	.008	.002	--	.002	.002	.002	.003	.003
7	.004	.002	.003	.003	.002	.002	.002	.003
8	.019	.001	--	.001	.001	.001	.001	.001
9	.002	.002	.001	.002	.001	.001	.001	.004
10	.021	.001	--	.002	.001	.001	.001	.002
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	.011	.002	.002	.002	.002	.002	.002	.005

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	.117	--	--	--
2	.004	.003	.002	.001	.001	.001	.001	--	.004	.004	--
3	.005	.002	.002	.002	.002	.002	.002	.040	.003	.002	--
4	.003	.001	.002	.001	.002	.001	.003	.144	.002	.004	.002
5	.001	.001	.001	.001	.001	.001	.001	--	.001	.001	.001
6	.002	.003	.002	.002	.002	.002	.002	.066	.003	.004	.003
7	.013	.006	.002	.002	.001	.002	.002	.258	.008	.006	.005
8	.006	.044	.003	.003	.001	.002	.002	.069	.003	.002	.001
9	.004	.003	.002	.004	.002	.002	.002	.073	.005	.004	.004
10	.003	.002	.001	.003	.001	.004	.002	.090	.005	.002	.002
11	.002	.002	.002	.002	.002	.002	.002	.075	.002	.002	.002
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	.004	.007	.002	.002	.002	.002	.002	.104	.004	.003	.003

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.029	--
2	--	.004
3	.078	.003
4	.019	.003
5	--	.001
6	.004	.003
7	.009	.006
8	.010	.003
9	.007	.006
10	.004	.003
11	.006	.002
12	--	--
AVG.	.018	.003

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	.023	.014	--	.011	.009	.009
2	1.910	.021	.010	--	.010	.008	.008
3	2.028	.021	--	--	.003	.003	.003
4	2.416	.113	.152	--	.005	.001	.001
5	1.690	.116	.083	.019	.007	.001	.001
6	1.098	.112	.030	.006	.002	.001	.001
7	.326	.016	.005	.005	.003	.005	.003
8	.215	.011	.005	.004	.005	.002	.002
9	.230	.009	.008	.005	.005	.003	.002
10	.146	.006	.005	.004	.004	.002	.002
11	.150	.006	.005	.004	.006	.003	.001
12	.194	.005	.006	.006	.005	--	--
AVG.	.946	.038	.029	.007	.005	.003	.003

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	.010	.006	.002	.003	.001	.012
3	.006	.010	.010	.003	.002	.002	.007
4	--	--	--	--	--	--	--
5	.004	.010	.006	.002	.002	.003	.003
6	.010	.005	.001	.002	.001	.003	.005
7	.005	.004	.002	.001	.001	.002	.002
8	.006	.004	.002	.002	.002	.002	.003
9	.008	.007	.001	.001	.002	.001	.001
10	--	--	--	--	--	--	--
11	.009	.007	.004	.002	.002	.002	.004
12	--	--	--	--	--	--	--
AVG.	.007	.007	.004	.002	.002	.002	.005

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	.004	.001	--	.001	--	.002	.008
3	.002	.003	.002	.002	.001	.002	.003	.011
4	--	--	--	--	--	--	--	--
5	.003	.002	.002	.001	.002	.001	.001	.002
6	.003	.003	.003	.004	.002	.003	.003	.022
7	.002	.002	.002	.002	.002	.002	.002	-.997
8	.002	.002	.002	.002	.007	.003	.003	.003
9	.002	.004	.002	.004	.003	.002	.004	.003
10	--	--	--	--	--	--	--	--
11	.003	.002	.002	.003	.004	.004	.004	.004
12	--	--	--	--	--	--	--	--
AVG.	.002	.003	.002	.003	.003	.002	.003	.008

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	.002	.003	.003	.002	.003	.003
2	.005	.002	.002	.002	.002	.002
3	.003	.002	.001	.001	.001	.001
4	.002	.001	.002	.001	.007	.005
5	.005	.004	.003	.002	.002	.002
6	.006	.006	.003	.002	.002	.002
7	.003	.003	.003	.002	.002	.002
8	.016	.003	.002	.001	.003	.002
9	.011	.003	.002	.002	.002	.002
10	--	.002	.002	.003	.002	.002
11	.007	.004	.002	.003	.004	.002
12	--	--	--	--	--	--
AVG.	.006	.003	.002	.002	.003	.002

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	.002	.003	.003	.003	.002	.003	.004
2	--	.002	.011	.004	.004	.002	.003	.005
3	--	.001	.005	.001	.003	.002	.002	.006
4	.034	.002	.007	.003	.003	.003	.002	.002
5	--	.002	.004	.001	.001	.001	.002	.005
6	--	.002	.003	.003	.001	.002	.002	.003
7	.011	.002	.002	.003	.002	.001	.002	.003
8	.029	.002	.002	.001	.002	.004	.006	.003
9	.013	.003	.002	.002	.002	.001	.002	.003
10	.008	.003	.003	.002	.001	.003	.001	.002
11	--	--	--	.002	.002	.002	.002	.004
12	--	--	--	--	--	--	--	--
AVG.	.019	.002	.004	.002	.002	.002	.002	.004

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	.003	.003	.002	.002	.002	.002	.004	.082	.002	.002	.003
2	.006	.002	.002	.003	.002	.002	.001	.088	.002	.003	.003
3	.017	.003	.002	.004	.003	.002	.002	.077	.002	.002	.001
4	.005	.002	.002	.002	.002	.002	.002	.093	.003	.002	.002
5	.007	.007	.003	.005	.003	.003	.003	.102	.004	.003	.003
6	.002	.002	.002	.002	.002	.002	.002	.144	.002	.002	.002
7	.005	.001	.001	.002	.002	.001	.001	.177	.002	.002	.003
8	.004	.003	.003	.002	.002	.002	--	.180	.003	.004	.002
9	.008	.001	.002	.002	.001	.002	.002	.091	.002	.002	.002
10	.002	.002	.001	.001	.001	.001	.001	.072	.001	.001	.001
11	.002	.001	.001	.001	.001	.002	.002	--	.002	.001	.001
12	.002	.003	.002	.002	.003	.002	.002	.063	.001	.002	.002
AVG.	.005	.003	.002	.002	.002	.002	.002	.106	.002	.002	.002

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.012	.002
2	.007	.002
3	.005	.002
4	.009	.003
5	.003	.003
6	.005	.002
7	.004	.003
8	.006	.005
9	.005	.002
10	.003	.001
11	--	.001
12	.010	.001
AVG.	.006	.002

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	.158	.005	.004	.005	.003	.007	.005
2	.191	.008	.007	.006	.005	.003	.005
3	.435	.014	.012	.003	.002	.003	.002
4	.368	.011	.010	.005	.003	.003	.003
5	.445	.009	.007	.004	.004	.003	.003
6	.449	.003	.003	.003	.003	.002	.002
7	.547	.008	.006	.003	.003	.002	.002
8	.628	.018	.012	.005	.004	.002	.003
9	.694	.014	.008	.005	.007	.002	.003
10	.572	.003	.004	.003	.002	.001	.001
11	.498	.009	.010	.006	.004	.002	.002
12	.439	.003	.003	.003	.002	.003	.002
AVG.	.452	.009	.007	.004	.003	.003	.003

Appendix Table B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1982

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	.008	.005	.003	.003	.002	.002	.002
2	--	--	--	--	--	--	--
3	.006	.005	.005	.002	.002	.002	.003
4	.002	.003	.003	.002	.002	.002	.003
5	.005	.004	.003	.003	.002	.002	.003
6	.003	.003	.002	.002	.002	.002	.002
7	.004	.004	.004	.002	.002	.002	.002
8	.004	.006	.003	.003	.003	.002	.004
9	.005	.002	.002	.003	.002	.003	.003
10	.005	.004	.003	.002	.003	.003	.007
11	.003	.004	.003	.003	.002	.002	.001
12	.006	.004	.002	.003	.002	.003	.003
AVG.	.005	.004	.003	.003	.002	.002	.003

Appendix Talbe B. (Cont.)

NUTRIENTS
ORTHO-PHOSPHORUS
(MG/L)
1932

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	.002	.005	.001	.001	.001	.001	.002	.002
2	--	--	--	--	--	--	--	--
3	.004	.002	.003	.002	.002	.002	.002	.003
4	.002	.003	.002	.003	.002	.002	.002	.003
5	.003	.003	.003	.003	.002	.003	.003	.003
6	--	--	--	--	--	--	--	--
7	.002	.002	.002	.003	.002	.002	.002	.002
8	.006	.008	.004	.004	.003	.004	.004	.003
9	.004	.003	.003	.002	.002	.002	.002	.002
10	.002	.002	.003	.003	.002	.003	.003	.007
11	.001	.001	.001	.001	.003	.002	.002	.002
12	.002	.002	.002	.002	.002	.002	.002	.003
AVG.	.003	.003	.002	.002	.002	.002	.002	.003

Appendix Table C. Monthly or average monthly total nitrogen concentrations in surface composite samples for reservoirs inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay station 14a (BC2) is 0-2.5 m integrated depth.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	.488	--	.491	--	.429
4	1.023	.479	.405	.425	.661	.418
5	.578	.696	.405	.350	--	.392
6	.813	.622	.524	.399	.277	.422
7	.749	.227	.373	.313	.194	.242
8	.900	.441	.324	.315	.272	.232
9	3.771	.461	.439	.316	.261	.258
10	3.568	.580	.603	.375	.635	.380
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	1.629	.499	.439	.373	.383	.347

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	.694	--	--	.405	.405	.450	.412	.570
4	.902	.510	--	.418	.479	.729	1.316	.642
5	1.190	.244	--	.390	.327	.512	1.611	.659
6	.594	.250	--	.316	.391	.258	.330	.431
7	.697	.257	.474	.254	.239	.328	.278	.513
8	1.857	.260	--	.220	.281	.468	.296	.613
9	.989	.282	.491	.150	.233	.270	.190	.731
10	.750	.407	--	.252	.288	.302	.225	.585
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	.959	.316	.483	.301	.330	.415	.582	.593

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY APM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	.663	--	--	--
2	.584	.623	.749	.547	.446	.446	.468	--	.525	.508	--
3	.478	.505	.474	.447	.416	.381	.422	.828	.388	.490	--
4	.506	.611	.525	.658	.451	.361	.340	.936	.371	.536	.320
5	.498	.527	.446	.429	.414	.366	.340	--	.270	.333	.303
6	.407	.411	.366	.431	.330	.240	.614	.440	.301	.245	.299
7	2.011	.355	.191	.236	.153	.120	.230	.406	.242	.275	.232
8	.806	.266	.192	.208	.192	.263	.204	.453	.232	.177	.189
9	.511	.247	.198	.217	.220	.254	.260	.769	.235	.131	.192
10	.768	.375	.288	.256	.255	.654	.295	1.338	.260	.191	.275
11	.430	.477	.384	.301	.324	.331	.520	.793	.258	.328	.404
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	.700	.440	.381	.373	.320	.342	.369	.736	.308	.321	.277

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.891	--
2	--	.429
3	1.150	.421
4	.756	.643
5	--	.311
6	.374	.322
7	13.489	.221
8	3.275	.198
9	1.553	.287
10	1.202	.255
11	2.618	.378
12	--	--
AVG.	2.812	.347

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	.656	.466	--	.502	.442	.439
2	13.180	.650	.607	--	.534	.457	.482
3	12.600	.688	--	--	.454	.458	.513
4	15.125	1.338	--	--	.388	.494	.480
5	10.858	1.329	1.010	.609	.413	.474	.440
6	11.836	2.172	1.155	.443	.183	.210	.252
7	7.660	.898	.838	.834	.323	.184	.186
8	7.138	1.076	.574	.422	.551	.280	.367
9	10.484	1.555	.564	.329	.363	.190	.287
10	5.996	.676	.648	.255	.270	.236	.226
11	7.686	.454	.377	.391	.301	.318	.364
12	8.416	.467	.450	.398	.398	--	--
AVG.	10.089	.996	.669	.460	.390	.340	.367

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	.443	.443	.447	.457	.475	.482
3	.483	.476	.509	.421	.340	.365	.328
4	--	--	--	--	--	--	--
5	.529	.565	.494	.324	.385	.403	.410
6	.495	.456	.332	.218	.228	.432	.382
7	.466	.436	.256	.271	.163	.387	.383
8	.423	.441	.277	.209	.246	.296	.469
9	.517	.565	.290	.266	.290	.338	.425
10	--	--	--	--	--	--	--
11	.517	.502	.560	.306	.279	.310	.317
12	--	--	--	--	--	--	--
AVG.	.490	.486	.395	.308	.299	.376	.400

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	.586	.447	--	.405	--	.398	.328
3	.444	.461	.433	.372	.454	.409	.440	.447
4	--	--	--	--	--	--	--	--
5	.416	.298	.305	.348	.202	.209	.209	.335
6	.359	.318	.287	.332	.287	.382	.368	.385
7	.337	.315	.259	.266	.245	.250	.192	.301
8	.528	.379	.333	.336	.578	.677	.364	.336
9	.437	.310	.386	.298	.405	.397	.362	.374
10	--	--	--	--	--	--	--	--
11	.368	.388	.384	.349	.322	.314	.314	.368
12	--	--	--	--	--	--	--	--
AVG.	.413	.382	.354	.329	.362	.377	.331	.359

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	.752	.571	.502	.457	.357	.446
2	1.431	.547	.522	.508	.421	.479
3	1.072	.541	.498	.668	.641	.544
4	1.082	1.257	.532	.466	.446	.446
5	.992	.770	.665	.435	.460	.382
6	.655	.462	.498	.658	.359	.440
7	.932	.544	.395	.575	.450	.684
8	1.748	.300	.238	.269	.432	.346
9	2.263	.567	.507	.335	.320	.428
10	--	.614	.588	.436	.436	.439
11	.618	.506	.524	.365	.470	.392
12	--	--	--	--	--	--
AVG.	1.155	.607	.497	.470	.436	.457

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	.451	.754	.411	.420	.414	.307	.396
2	--	.441	1.289	.486	.468	.448	.458	.525
3	--	.511	1.238	.194	.551	.684	.521	.512
4	.828	.768	1.059	.505	.499	.499	.446	.630
5	--	.419	.449	.342	.354	.367	.380	.640
6	--	.562	.268	.360	.380	.373	.417	.584
7	.404	.380	.435	.542	.614	.373	.334	.622
8	2.280	.211	.284	.408	.452	.548	.888	.723
9	1.007	.380	.404	.149	.376	.303	.281	.707
10	.497	.356	.380	.386	.449	.370	.324	.535
11	--	--	--	.374	.350	.338	.310	.563
12	--	--	--	--	--	--	--	--
AVG.	1.003	.448	.656	.378	.447	.429	.427	.585

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
	LOCATION/STATION										
1	.224	.220	.309	.207	.323	.245	.308	.636	.344	.698	.399
2	.411	.417	.401	.392	.408	.398	.389	.579	.398	.374	.403
3	.572	.547	.535	.532	.582	.476	.423	1.064	.352	.411	.520
4	.443	.443	.413	.422	.425	.586	.351	.933	.336	.410	.402
5	.891	.425	.397	.518	.404	.368	.427	.877	.467	.740	.425
6	.514	.362	.411	.312	.376	.406	.362	.727	.340	.372	.397
7	.820	.437	.691	.386	.379	.386	.437	1.468	.306	.483	.401
8	.917	.161	.104	.204	.264	.232	--	.846	.232	.232	.200
9	.638	.400	.432	.584	.366	.326	.277	.738	.211	.214	.234
10	.872	.240	.244	.392	.268	.319	.374	.733	.258	.271	.392
11	.594	.396	.342	.326	.313	.543	.409	--	.326	.501	.390
12	.529	.516	.448	.621	.451	.448	.380	.977	.380	.353	.384
AVG.	.619	.385	.394	.409	.380	.402	.376	.871	.329	.422	.372

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	1.006	.393
2	.852	.433
3	1.474	.448
4	1.032	.360
5	.621	.546
6	.223	.347
7	.310	.247
8	2.377	.227
9	1.549	.211
10	.926	.247
11	--	.281
12	1.604	.326
AVG.	1.089	.339

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	---	.494	.479	.440	.351	.405	.396
2	8.592	.542	.447	.423	.518	.691	.426
3	7.560	.729	.653	.435	.536	.434	.656
4	7.723	.732	.542	.378	.413	.431	.554
5	6.424	.798	.712	.664	.518	.440	.346
6	8.008	.597	.430	.383	.250	.332	.325
7	8.390	.825	.689	.409	.325	.302	.272
8	---	.973	.781	.530	.362	.283	.229
9	9.040	.630	.480	.344	.248	.197	.227
10	6.388	.502	.436	.368	.319	.274	.290
11	6.748	.709	.508	.456	.332	.342	.409
12	7.194	.686	.658	.288	.529	.367	.373
AVG.	7.607	.685	.568	.426	.392	.375	.375

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	.415	.316	.366	.273	.373	.345	.361
2	--	--	--	--	--	--	--
3	.424	.482	.453	.434	.431	.421	.440
4	.499	.472	.446	.449	.399	.396	.560
5	.465	.512	.417	.404	.390	.411	.342
6	.482	.440	.256	.239	.213	.434	.440
7	.422	.758	.280	.226	.248	.328	.401
8	.656	1.044	.357	.273	.380	.402	.541
9	.545	..513	.310	.266	.323	.408	.466
10	.473	.487	.531	.409	.365	.337	.687
11	.369	.388	.393	.344	.289	.404	.353
12	.427	.419	.359	.416	.359	.363	.347
AVG.	.471	.530	.379	.339	.343	.386	.449

Appendix Table C. (Cont.)

NUTRIENTS
TOTAL-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	.376	.364	.448	.342	.335	.373	.342	.379
2	--	--	--	--	--	--	--	--
3	.485	.454	.445	.475	.376	.351	.341	.412
4	.403	.419	.403	.412	.386	.346	.386	.354
5	.448	.396	.308	.296	.336	.368	.216	.276
6	--	--	--	--	--	--	--	--
7	.487	.462	.293	.317	.314	.302	.259	.376
8	.719	.772	.333	.323	.389	.363	.392	.402
9	.738	.660	.401	.434	.329	.349	.280	.349
10	.382	.437	.347	.412	.400	.347	.450	.325
11	.262	.262	.237	.277	.267	.374	.298	.253
12	.313	.276	.280	.296	.223	.303	.296	.241
AVG.	.461	.450	.349	.358	.335	.348	.326	.337

Appendix Table D. Monthly or average monthly ammonia concentrations in surface composite samples for reservoirs inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay station 14a (BC2) is 0-2.5 m integrated depth.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	.008	--	.005	--	.019
4	.039	.016	.008	.010	.006	.008
5	.005	.014	.008	.010	--	.006
6	.017	.018	.018	.003	.008	.007
7	.007	.010	.019	.019	.007	.006
8	.013	.007	.006	.006	.003	.004
9	.035	.018	.033	.012	.007	.015
10	.009	.013	.006	.007	.014	.005
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	.018	.013	.014	.009	.008	.009

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	.012	--	--	.007	.007	.008	.009	.005
4	.023	.008	--	.005	.004	.006	.005	.002
5	.007	.011	--	.015	.003	.005	.004	.008
6	.009	.009	--	.005	.006	.001	.003	.002
7	.002	.005	.021	.012	.012	.005	.003	.011
8	.016	.004	--	.005	.009	.003	.003	.002
9	.031	.022	.032	.007	.003	.005	.006	.013
10	.011	.010	--	.007	.013	.015	.017	.011
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	.014	.010	.027	.008	.007	.006	.006	.007

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	.231	--	--	--
2	.002	.002	.005	.010	.001	.003	.002	--	.006	.003	--
3	.008	.005	.009	.006	.007	.007	.005	.104	.006	.005	--
4	.012	.004	.007	.007	.004	.005	.003	.021	.005	.003	.005
5	.010	.009	.013	.009	.005	.008	.003	--	.004	.007	.003
6	.004	.002	.005	.003	.002	.003	.007	.031	.007	.005	.005
7	.052	.008	.007	.008	.007	.006	.012	.042	.015	.007	.005
8	.005	.002	.002	.001	.002	.003	.006	.107	.012	.005	.004
9	.002	.009	.002	.005	.002	.014	.005	.094	.001	.005	.001
10	.004	.005	.004	.004	.003	.019	.012	.121	.012	.007	.003
11	.014	.005	.016	.014	.008	.003	.003	.063	.004	.007	.004
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	.011	.005	.007	.007	.004	.007	.006	.090	.007	.005	.004

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.073	--
2	--	.004
3	.066	.008
4	.010	.007
5	--	.008
6	.004	.008
7	.008	.007
8	.063	.004
9	.013	.004
10	.029	.003
11	.054	.006
12	--	--
AVG.	.036	.006

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	.116	.079	--	.018	.010	.034
2	9.400	.129	.040	--	.013	.005	.003
3	8.950	.074	--	--	.015	.014	.027
4	9.167	.248	--	--	.008	.012	.014
5	7.409	.617	.198	.027	.040	.005	.014
6	6.952	.809	.225	.015	.014	.008	.002
7	3.905	.080	.071	.006	.005	.004	.001
8	3.427	.169	.079	.025	.023	.004	.002
9	3.245	.012	.012	.004	.002	.003	.005
10	2.214	.085	.033	.008	.005	.009	.006
11	1.654	.051	.028	.016	.017	.020	.006
12	3.740	.046	.030	.027	.024	--	--
AVG.	5.460	.203	.080	.016	.015	.008	.010

Appendix Table D. (Cont.)

****
* NUTRIENTS *
* AMMONIA-NITROGEN *
* (MG/L) *
* 1981 *
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LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	.009	.003	.002	.014	.020	.026
3	.005	.007	.00[illegible]	.009	.016	.003	.019
4	--	--	--	--	--	--	--
5	.013	.023	.016	.034	.009	.019	.021
6	.007	.012	.060	.008	.032	.008	.021
7	.004	.010	.010	.005	.003	.010	.028
8	.003	.018	.005	.005	.009	.024	.019
9	.002	.008	.005	.006	.004	.006	.015
10	--	--	--	--	--	--	--
11	.005	.013	.010	.006	.003	.003	.007
12	--	--	--	--	--	--	--
AVG.	.006	.012	.015	.009	.011	.012	.020

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	.010	.009	--	.012	--	.021	.020
3	.011	.010	.005	.004	.007	.015	.014	.019
4	--	--	--	--	--	--	--	--
5	.006	.008	.015	.011	.012	.015	.011	.021
6	.006	.005	.002	.002	.007	.014	.011	.029
7	.012	.012	.007	.006	.007	.005	.004	.024
8	.011	.008	.010	.008	.010	.010	.013	.026
9	.010	.006	.011	.006	.003	.015	.007	.031
10	--	--	--	--	--	--	--	--
11	.006	.006	.018	.031	.018	.030	.008	.053
12	--	--	--	--	--	--	--	--
AVG.	.009	.008	.010	.010	.009	.015	.011	.028

Appendix TAble D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	.126	.009	.008	.007	.008	.007
2	.123	.004	.005	.005	.004	.002
3	.040	.011	.015	.020	.014	.010
4	.010	.021	.017	.011	.006	.006
5	.024	.012	.047	.012	.004	.009
6	.002	.008	.012	.013	.004	.010
7	.016	.010	.008	.014	.008	.015
8	.022	.020	.118	.008	.006	.010
9	.018	.008	.006	.007	.007	.008
10	--	.013	.011	.012	.012	.009
11	.008	.014	.004	.014	.006	.004
12	--	--	--	--	--	--
AVG.	.039	.012	.023	.011	.007	.008

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	.014	.097	.007	.009	.008	.010	.013
2	--	.008	.058	.008	.013	.004	.006	.009
3	--	.012	.044	.012	.010	.009	.014	.012
4	.033	.014	.010	.011	.008	.006	.006	.004
5	--	.007	.017	.003	.009	.003	.001	.008
6	--	.007	.006	.007	.007	.008	.007	.008
7	.003	.007	.007	.005	.010	.003	.005	.003
8	.034	.004	.004	.002	.006	.009	.019	.010
9	.010	.007	.010	.006	.004	.006	.018	.008
10	.008	.012	.017	.009	.009	.008	.010	.008
11	--	--	--	.002	.005	.004	.009	.003
12	--	--	--	--	--	--	--	--
AVG.	.018	.009	.027	.007	.008	.006	.010	.008

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	.008	.006	.006	.011	.005	.005	.004	.067	.009	.007	.007
2	.009	.006	.005	.016	.008	.006	.005	.110	.013	.016	.020
3	.005	.006	.026	.020	.014	.004	.004	.110	.006	.007	.009
4	.013	.006	.009	.012	.014	.007	.008	.070	.007	.009	.003
5	.010	.004	.019	.012	.011	.007	.005	.038	.006	.011	.011
6	.007	.007	.007	.005	.005	.004	.004	.050	.006	.005	.006
7	.011	.006	.005	.005	.007	.005	.005	.071	.005	.004	.003
8	.006	.003	.001	.002	.004	.001	--	.074	.010	.003	.003
9	.007	.006	.010	.004	.004	.006	.008	.166	.004	.005	.014
10	.009	.009	.021	.014	.008	.008	.011	.065	.007	.006	.010
11	.008	.013	.016	.015	.009	.006	.008	--	.004	.004	.001
12	.006	.005	.004	.009	.007	.006	.005	.079	.003	.005	.004
AVG.	.008	.006	.011	.010	.008	.005	.006	.032	.007	.007	.009

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.056	.013
2	.037	.007
3	.053	.016
4	.026	.028
5	.020	.012
6	.009	.007
7	.003	.003
8	.005	.003
9	.036	.034
10	.046	.008
11	--	.004
12	.069	.007
AVG.	.033	.012

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	2.428	.024	.020	.013	.009	.003	.005
2	5.972	.080	.032	.016	.011	.005	.006
3	3.840	.145	.104	.014	.006	.017	.023
4	4.120	.040	.035	.009	.011	.011	.013
5	2.500	.080	.084	.042	.025	.006	.008
6	2.779	.026	.028	.013	.008	.005	.006
7	3.429	.078	.052	.011	.009	.007	.009
8	3.405	.051	.032	.015	.007	.021	.003
9	3.385	.062	.047	.007	.006	.005	.003
10	2.710	.040	.047	.016	.014	.008	.010
11	2.005	.025	.045	.032	.007	.010	.005
12	3.046	.027	.020	.011	.011	.009	.009
AVG.	3.302	.056	.045	.017	.010	.009	.008

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	.003	.008	.004	.010	.032	.012	.009
2	--	--	--	--	--	--	--
3	.008	.005	.006	.009	.015	.012	.016
4	.007	.001	.005	.008	.009	.009	.037
5	.012	.002	.003	.003	.004	.013	.028
6	.002	.005	.003	.002	.002	.014	.038
7	.008	.007	.005	.005	.005	.005	.014
8	.005	.006	.011	.005	.006	.011	.018
9	.012	.012	.002	.004	.002	.004	.008
10	.009	.009	.011	.010	.018	.026	.028
11	.006	.019	.006	.011	.016	.024	.020
12	.005	.003	.005	.005	.004	.013	.020
AVG.	.007	.007	.006	.007	.010	.013	.021

Appendix Table D. (Cont.)

NUTRIENTS
AMMONIA-NITROGEN
(MG/L)
1982

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	.010	.006	.020	.005	.001	.003	.011	.020
2	--	--	--	--	--	--	--	--
3	.012	.011	.008	.012	.016	.013	.014	.021
4	.016	.013	.005	.001	.005	.008	.011	.016
5	.014	.010	.003	.004	.007	.008	.009	.032
6	--	--	--	--	--	--	--	--
7	.021	.017	.005	.008	.008	.008	.010	.026
8	.013	.009	.006	.007	.006	.006	.011	.032
9	.011	.011	.004	.006	.004	.003	.008	.034
10	.015	.013	.031	.012	.020	.013	.037	.040
11	.010	.013	.009	.012	.016	.011	.027	.035
12	.007	.006	.004	.008	.007	.010	.012	.016
AVG.	.013	.011	.009	.008	.009	.008	.015	.027

Appendix Table E. Monthly or average monthly nitrate and nitrite concentrations in surface composite samples for reservoir inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay station 14a (BC2) is 0-2.5 m integrated depth.)

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*         NUTRIENTS          *
*      NITRATE-NITROGEN      *
*          (MG/L)            *
*           1981             *
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LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	.262	--	.271	--	.226
4	.290	.233	.249	.224	.269	.267
5	.190	.360	.147	.201	--	.215
6	.249	.192	.347	.186	.103	.119
7	.236	.046	.152	.129	.092	.063
8	.380	.241	.199	.164	.057	.067
9	1.192	.174	.189	.122	.088	.003
10	.800	.265	.297	.195	.174	.109
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	.477	.222	.226	.187	.131	.134

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	.421	--	--	.262	.281	.287	.220	.439
4	.655	.103	--	.285	.269	.262	.233	.390
5	.694	.126	--	.219	.190	.162	.157	.344
6	.418	.057	--	.089	.133	.084	.066	.344
7	.467	.006	.246	.013	.085	.075	.061	.427
8	.524	.068	--	.023	.113	.052	.001	.160
9	.456	.035	.183	.010	.036	.034	.022	.347
10	.315	.146	--	.042	.081	.063	.042	.380
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	.494	.077	.215	.118	.149	.127	.100	.354

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	.368	--	--	--
2	.324	.300	.315	.220	.245	.265	.267	--	.215	.208	--
3	.337	.313	.289	.259	.280	.270	.264	.375	.198	.235	--
4	.321	.303	.289	.312	.272	.267	.276	.334	.205	.244	.233
5	.251	.231	.224	.208	.190	.153	.210	--	.196	.192	.240
6	.250	.163	.176	.170	.182	.172	.129	.085	.107	.119	.144
7	.558	.174	.079	.105	.112	.138	.106	.105	.046	.058	.080
8	.554	.110	.030	.081	.089	.122	.031	.170	.005	.014	.038
9	.216	.057	.026	.042	.054	.076	.064	.644	.034	.008	.016
10	.335	.126	.068	.082	.108	.102	.128	.658	.038	.054	.080
11	.392	.259	.146	.162	.177	.207	.198	.410	.101	.106	.149
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	.354	.204	.164	.164	.171	.177	.172	.350	.115	.124	.123

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.581	--
2	--	.220
3	.518	.224
4	.451	.227
5	--	.173
6	.006	.089
7	.571	.028
8	.360	.017
9	.461	.008
10	.613	.040
11	.705	.100
12	--	--
AVG.	.474	.113

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	.232	.215	--	.223	.267	.233
2	3.330	.278	.257	--	.233	.287	.275
3	2.169	.177	--	--	.222	.233	.244
4	3.524	.509	--	--	.226	.254	.276
5	2.332	.496	.354	.111	.098	.125	.159
6	4.745	1.372	.515	.071	.001	.001	.013
7	4.530	.319	.192	.067	.027	.002	.002
8	2.131	.270	.083	.019	.100	.002	.001
9	5.680	.212	.138	.034	.021	.002	.010
10	2.875	.200	.114	.066	.058	.044	.071
11	5.713	.204	.168	.163	.148	.162	.127
12	5.021	.231	.200	.213	.214	--	--
AVG.	3.823	.375	.224	.093	.131	.125	.128

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	.293	.267	.214	.209	.221	.184
3	.262	.254	.272	.139	.218	.162	.183
4	--	--	--	--	--	--	--
5	.375	.314	.319	.218	.175	.193	.200
6	.355	.304	.025	.118	.124	.159	.346
7	.336	.334	.026	.011	.006	.030	.251
8	.339	.226	.091	.001	.006	.005	.108
9	.332	.273	.001	.001	.001	.002	.232
10	--	--	--	--	--	--	--
11	.349	.326	.223	.060	.065	.136	.162
12	--	--	--	--	--	--	--
AVG.	.335	.291	.153	.095	.101	.113	.208

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	.180	.171	--	.169	--	.160	.168
3	.194	.184	.132	.168	.172	.168	.135	.156
4	--	--	--	--	--	--	--	--
5	.220	.213	.176	.191	.177	.162	.142	.164
6	.181	.176	.152	.149	.136	.038	.113	.147
7	.186	.197	.064	.056	.060	.046	.036	.133
8	.165	.154	.045	.038	.024	.005	.005	.049
9	.198	.220	.001	.001	.001	.001	.020	.086
10	--	--	--	--	--	--	--	--
11	.160	.155	.083	.061	.051	.041	.044	.047
12	--	--	--	--	--	--	--	--
AVG.	.186	.185	.103	.095	.099	.066	.082	.119

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	.546	.399	.381	.321	.291	.308
2	.444	.289	.339	.313	.299	.263
3	.492	.334	.307	.283	.249	.277
4	.306	.316	.293	.265	.283	.259
5	.307	.415	.454	.298	.273	.206
6	.241	.220	.256	.295	.333	.205
7	.208	.086	.137	.187	.186	.255
8	.780	.167	.071	.119	.133	.230
9	.731	.272	.287	.132	.107	.132
10	--	.347	.351	.225	.227	.202
11	.258	.367	.303	.277	.280	.261
12	--	--	--	--	--	--
AVG.	.431	.292	.289	.247	.242	.235

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	.382	.538	.278	.231	.243	.190	.296
2	--	.247	.906	.235	.265	.259	.170	.330
3	--	.239	.732	.268	.269	.268	.228	.400
4	.278	.265	.545	.255	.277	.297	.252	.460
5	--	.244	.228	.217	.213	.234	.278	.487
6	--	.106	.020	.148	.202	.187	.198	.387
7	.089	.015	.018	.142	.206	.139	.109	.355
8	1.233	.011	.069	.074	.192	.200	.424	.430
9	.592	.117	.129	.036	.138	.113	.113	.383
10	.318	.170	.140	.136	.218	.174	.124	.388
11	--	--	--	.189	.275	.177	.170	.416
12	--	--	--	--	--	--	--	--
AVG.	.502	.180	.333	.180	.226	.208	.205	.394

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	.186	.232	.235	.198	.226	.159	.251	.310	.157	.143	.166
2	.255	.272	.275	.243	.278	.263	.275	.252	.220	.220	.197
3	.326	.268	.227	.254	.254	.272	.272	.535	.224	.214	.261
4	.335	.283	.162	.194	.213	.236	.230	.430	.222	.242	.237
5	.331	.264	.252	.230	.242	.263	.236	.402	.219	.258	.221
6	.320	.173	.142	.178	.162	.150	.114	.225	.111	.162	.154
7	.317	.082	.052	.098	.102	.050	.090	.079	.046	.087	.091
8	.399	.050	.005	.029	.031	.066	--	.182	.011	.035	.066
9	.358	.011	.079	.006	.008	.040	.042	.291	.009	.014	.087
10	.365	.035	.023	.052	.061	.124	.137	.408	.035	.072	.102
11	.356	.172	.137	.121	.150	.180	.190	--	.133	.140	.176
12	.389	.260	.274	.197	.206	.211	.212	.431	.161	.148	.219
AVG.	.332	.175	.155	.149	.161	.168	.186	.322	.129	.145	.159

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	.844	.153
2	.655	.220
3	.635	.245
4	.675	.243
5	.494	.288
6	.026	.127
7	.004	.018
8	.494	.005
9	.528	.009
10	.698	.036
11	--	.136
12	.666	.192
AVG.	.520	.139

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	5.305	.255	.268	.247	.254	.215	.282
2	2.282	.257	.178	.242	.242	.242	.213
3	2.508	.426	.389	.289	.279	.240	.248
4	3.354	.265	.227	.203	.207	.257	.238
5	3.710	.475	.445	.357	.334	.301	.298
6	5.132	.150	.135	.078	.081	.114	.107
7	5.458	.347	.263	.052	.039	.031	.050
8	6.818	.503	.341	.129	.028	.018	.060
9	5.371	.214	.171	.015	.011	.012	.009
10	2.985	.146	.158	.088	.075	.075	.067
11	4.777	.156	.136	.093	.093	.112	.121
12	3.842	.199	.182	.200	.189	.202	.197
AVG.	4.295	.283	.241	.166	.153	.152	.158

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1982

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	.310	.304	.160	.219	.224	.166	.139
2	--	--	--	--	--	--	--
3	.295	.277	.267	-.785	.210	.171	.191
4	.274	.269	.235	.183	.182	.178	.179
5	.338	.305	.248	.191	.187	.227	.269
6	.305	.302	.062	.057	.054	.206	.256
7	.316	.334	.010	.009	.035	.044	.216
8	.288	.364	.005	.001	.001	.007	.215
9	.289	.093	.015	.024	.019	.120	.195
10	.312	.286	.278	.085	.043	.079	.081
11	.362	.269	.275	.172	.125	.125	.131
12	.290	.297	.299	.263	.175	.168	.111
AVG.	.307	.282	.169	.120	.114	.136	.180

Appendix Table E. (Cont.)

NUTRIENTS
NITRATE-NITROGEN
(MG/L)
1992

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	.155	.153	.157	.134	.130	.123	.116	.094
2	--	--	--	--	--	--	--	--
3	.178	.185	.183	.192	.183	.176	.160	.161
4	.191	.184	.171	.168	.179	.180	.170	.183
5	.271	.273	.198	.186	.187	.162	.154	.183
6	--	--	--	--	--	--	--	--
7	.262	.249	.131	.142	.110	.103	.096	.154
8	.195	.212	.022	.009	.005	.005	.001	.056
9	.298	.167	.044	.052	.026	.013	.024	.059
10	.142	.116	.051	.019	.042	.074	.042	.105
11	.077	.117	.094	.072	.084	.083	.073	.075
12	.154	.147	.126	.128	.104	.101	.079	.082
AVG.	.192	.180	.118	.110	.105	.102	.091	.115

Appendix Table F. Monthly or average monthly Chlorphyll-a concentrations in surface composite samples for reservoir inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982. (The inner Las Vegas Bay station 14a (BC2) is 0-2.5 m integrated depth.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

LOCATION/STATION

MONTH	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--
2	--	--	--	--	--
3	2.466	--	2.749	--	1.711
4	2.593	1.592	.665	1.016	1.440
5	2.197	2.928	1.768	--	1.928
6	2.671	5.510	4.643	4.592	4.205
7	8.617	5.266	2.473	2.002	1.579
8	10.081	5.033	2.342	1.886	1.783
9	7.693	5.263	3.632	3.016	2.349
10	4.858	4.495	3.219	1.798	2.710
11	--	--	--	--	--
12	--	--	--	--	--
AVG.	5.147	4.298	2.686	2.385	2.213

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5
1	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--
3	--	--	--	.899	1.022	.566	1.348
4	--	5.522	--	1.312	1.940	1.415	1.444
5	--	1.566	--	1.711	1.355	1.478	1.478
6	279.268	3.654	--	3.045	3.375	1.248	1.258
7	--	8.320	6.165	1.667	1.901	2.743	2.233
8	--	3.729	--	1.334	1.495	1.732	1.977
9	--	5.359	6.819	1.900	2.748	1.464	1.211
10	--	6.671	--	2.261	2.421	1.349	2.247
11	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--
AVG.	279.268	4.974	6.492	1.766	2.032	1.499	1.650

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

LOCATION/STATION

MONTH	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C	VIRGIN BOWL 13A
1	--	--	--	--	--	--	--	--	--	--
2	4.829	1.450	1.682	2.233	1.000	1.000	1.219	1.335	--	1.437
3	1.757	1.422	1.306	1.190	.936	.880	1.553	.769	--	.987
4	1.463	1.218	1.218	1.000	.573	.682	1.668	.769	.653	1.552
5	1.566	1.464	1.784	2.916	1.929	1.697	1.580	1.000	1.348	3.918
6	1.871	--	2.204	1.371	.565	.653	1.321	.986	.849	2.321
7	5.062	1.784	2.683	1.340	.630	.450	2.468	1.567	.668	3.033
8	5.061	3.713	4.263	2.807	1.464	--	--	--	--	--
9	6.976	2.146	5.511	2.798	1.580	.855	4.264	3.147	1.703	5.293
10	5.293	5.496	3.580	1.869	.999	1.000	2.840	1.463	1.123	3.796
11	3.233	4.015	1.884	.942	.869	.652	1.550	1.101	.985	1.769
12	--	--	--	--	--	--	--	--	--	--
AVG.	3.711	2.523	2.612	1.847	1.059	.874	2.051	1.349	1.047	2.678

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

LOCATION/STATION

MONTH	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	.755	.756	--	1.328	.886	.661
2	.595	.653	--	1.334	1.349	1.450
3	17.291	--	--	6.091	1.670	1.567
4	39.526	--	--	5.794	.448	.218
5	57.829	15.500	13.074	9.916	2.205	2.044
6	50.199	44.843	16.280	3.483	.900	1.785
7	52.525	48.922	19.671	9.569	.856	2.120
8	59.464	47.227	14.049	6.749	1.241	1.206
9	39.767	28.253	7.297	9.930	1.273	1.044
10	4.105	3.568	4.518	3.911	2.227	2.220
11	2.530	2.321	2.052	1.826	1.253	1.202
12	.654	1.140	2.335	1.054	--	--
AVG.	27.103	18.500	9.909	5.082	1.301	1.411

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

	LOCATION/STATION					
MONTH	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--
2	.667	3.408	5.945	2.988	5.294	5.105
3	.654	.770	5.368	2.191	2.118	2.212
4	--	--	--	--	--	--
5	.554	1.438	1.785	1.544	1.321	1.335
6	.653	6.354	4.034	2.648	1.582	.900
7	1.103	7.299	4.568	2.509	5.324	3.264
8	.912	4.582	2.581	1.921	2.364	1.798
9	1.453	5.105	6.816	4.895	6.845	2.916
10	--	--	--	--	--	--
11	.815	3.795	7.428	5.782	4.797	4.166
12	--	--	--	--	--	--
AVG.	.851	4.094	4.816	3.060	3.706	2.712

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1981

LOCATION/STATION

MONTH	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--
2	--	6.178	--	1.683	--	2.364	2.017
3	1.799	1.801	1.582	1.335	.784	1.567	2.000
4	1.231	1.014	1.581	1.116	.537	.898	1.181
5	--	--	--	--	--	--	--
6	1.450	1.565	1.566	1.109	.783	1.247	1.355
7	3.749	3.677	3.647	3.263	3.082	4.888	4.434
8	2.683	4.213	5.265	4.257	3.931	5.962	5.178
9	2.916	6.265	6.599	6.026	5.932	9.426	5.716
10	--	--	--	--	--	--	--
11	3.032	5.143	4.366	5.591	5.049	7.514	5.572
12	--	--	--	--	--	--	--
AVG.	2.409	3.732	3.515	3.047	2.871	4.233	3.431

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

	LOCATION/STATION				
MONTH	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	2.370	1.565	1.724	1.666	1.246
2	2.678	3.540	1.609	2.244	2.609
3	1.515	1.768	1.648	1.334	1.131
4	1.661	1.682	.920	1.305	1.030
5	6.786	3.506	3.488	3.450	2.044
6	5.658	7.419	2.662	1.667	1.639
7	8.316	1.901	1.981	1.538	1.873
8	9.727	7.225	5.801	4.296	2.872
9	9.590	4.789	4.267	--	4.821
10	3.510	3.379	1.805	1.580	1.697
11	--	--	--	.985	1.638
12	1.537	1.086	.986	--	--
AVG.	4.850	3.442	2.444	2.007	2.055

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

LOCATION/STATION

MONTH	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5
1	1.951	.084	.912	1.993	1.231	1.007
2	2.967	4.342	2.595	3.426	1.891	2.349
3	2.334	--	1.130	1.051	.674	.863
4	1.769	5.485	1.044	1.269	.798	1.066
5	2.914	5.365	2.288	2.551	1.261	1.624
6	1.763	11.470	1.320	1.241	.986	.986
7	3.177	4.772	1.089	1.546	1.205	1.248
8	3.335	10.256	2.756	3.547	2.088	2.153
9	9.315	12.393	1.103	3.374	1.653	1.146
10	1.698	2.937	--	1.761	1.247	1.072
11	--	--	1.421	1.421	1.189	.856
12	--	--	--	--	--	--
AVG.	3.122	6.345	1.566	2.107	1.293	1.306

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

LOCATION/STATION

MONTH	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C	VIRGIN BOWL 13A
1	1.698	2.885	1.871	1.726	1.422	1.161	1.319	1.231	1.203	--
2	2.465	2.204	1.987	1.391	1.434	1.558	1.102	.999	1.378	1.769
3	5.743	2.306	4.016	1.450	.653	.820	1.769	1.088	.856	1.203
4	5.394	7.524	8.742	3.754	.782	.528	1.914	1.479	.522	1.827
5	3.843	2.335	2.000	1.631	1.110	.531	3.931	1.218	--	3.844
6	2.205	2.321	2.437	1.829	2.340	1.037	1.886	1.102	1.269	2.466
7	3.219	1.871	2.320	1.379	1.088	1.139	2.639	1.074	1.182	4.134
8	3.148	2.348	2.580	1.682	.885	--	2.349	1.218	.828	3.335
9	5.294	4.192	6.992	3.082	3.219	1.501	2.299	2.394	1.508	4.761
10	3.698	2.901	3.117	2.343	1.218	1.102	2.304	1.321	1.102	2.132
11	3.467	2.668	1.434	1.333	1.334	.883	1.794	.986	.870	2.335
12	1.884	3.583	1.553	1.437	.885	.769	1.552	1.203	.885	2.233
AVG.	3.505	3.095	3.254	1.920	1.364	1.002	2.071	1.276	1.055	2.731

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

LOCATION/STATION

MONTH	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	1.429	1.850	1.828	2.001	1.182	1.291
2	.755	.799	.964	1.058	3.009	5.728
3	1.886	2.365	7.476	7.236	.863	.812
4	33.224	20.149	6.410	3.402	1.247	1.218
5	16.482	16.248	9.483	7.249	1.464	.972
6	57.081	20.958	4.089	3.328	1.166	2.233
7	29.737	23.831	7.542	4.216	1.352	1.107
8	53.800	40.129	19.734	10.854	1.299	1.758
9	25.051	18.400	8.396	6.317	1.066	.914
10	14.673	12.957	6.717	3.778	1.740	2.684
11	.792	.450	.573	1.189	.675	.914
12	.936	1.147	1.224	1.321	.878	.654
AVG.	19.654	13.274	6.203	4.329	1.328	1.690

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

LOCATION/STATION

MONTH	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	1.914	3.619	5.365	2.466	3.815	3.706
2	--	--	--	--	--	--
3	.624	1.055	3.103	1.551	1.792	2.270
4	.261	1.443	1.550	.696	.580	1.030
5	.522	1.501	1.321	1.443	.783	1.740
6	--	--	--	--	--	--
7	.775	5.344	2.183	1.983	2.894	2.230
8	0.000	3.895	3.291	2.778	3.641	1.538
9	5.312	5.047	4.481	5.206	3.001	1.711
10	.870	.718	2.887	3.169	2.001	2.560
11	.436	2.611	2.192	2.104	1.785	.873
12	.986	2.123	3.203	3.293	3.684	3.531
AVG.	1.170	2.736	2.958	2.469	2.398	2.119

Appendix Table F. (Cont.)

CHLOROPHYLL-A
(MICRO-GRAMS/LITER)
1982

LOCATION/STATION

MONTH	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	3.523	3.583	4.481	3.125	4.408	3.945	3.285
2	--	--	--	--	--	--	--
3	1.959	2.259	3.263	2.331	1.566	1.616	1.722
4	1.180	1.676	1.625	.827	.667	.668	1.551
5	1.553	1.102	1.885	1.154	.885	.770	1.262
6	2.121	2.487	2.030	1.791	1.552	2.002	2.196
7	2.233	4.089	8.582	4.250	3.799	4.253	3.634
8	2.451	5.398	7.208	4.910	3.844	4.424	2.670
9	2.977	3.698	7.079	5.986	5.946	6.280	3.916
10	2.001	2.996	3.902	3.749	3.104	3.336	3.837
11	.696	2.584	2.468	3.048	4.295	5.571	4.281
12	1.669	2.784	2.684	2.742	3.684	5.484	4.134
AVG.	2.033	2.969	4.110	3.083	3.068	3.486	2.953

Appendix Table G. Monthly or average monthly Phytoplankton productivity in Lake Mead, Lake Mohave and Lake Havasu during 1981 and 1982.

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* PHYTOPLANKTON PRODUCTIVITY *
*       (MG C/M-2/DAY)       *
*           1981             *
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LOCATION/STATION

MNTH	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B	INNER LVB2 BC2	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	--	--	--	--	--	--	--	253.93	173.95	153.37
2	22.10	253.62	305.28	202.45	211.87	--	--	--	274.31	275.82	267.83
3	70.60	347.34	355.41	194.70	227.96	188.30	190.66	2307.07	1434.99	351.30	--
4	52.71	367.81	372.03	234.93	283.73	290.77	373.02	4460.13	2816.66	415.64	--
5	116.81	750.98	983.33	968.61	767.05	394.35	662.29	2139.12	3328.10	1778.72	--
6	170.71	854.07	740.58	538.99	573.69	481.61	--	4237.18	2370.85	1244.73	--
7	122.97	944.20	756.01	465.62	609.02	592.51	803.79	3428.01	3608.66	1223.95	--
8	60.17	469.02	336.66	189.97	192.46	496.81	512.35	3666.72	1298.12	251.42	--
9	73.36	601.24	407.47	232.99	258.81	431.42	574.23	3621.44	1373.80	251.42	--
10	164.72	493.46	193.16	135.22	172.23	191.62	203.82	520.80	616.21	417.58	--
11	82.87	330.36	204.78	92.83	90.90	74.83	135.44	140.42	356.82	169.92	--
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	93.70	541.71	465.47	325.63	338.77	349.14	431.95	2724.54	1612.04	595.86	210.60

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1981

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1		--
2		--
3		185.20
4		324.54
5		413.98
6		627.74
7		723.48
8		482.18
9		456.61
10		192.30
11		128.09
12		--
AVG.		392.68

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1981

LOCATION/STATION

MONTH	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19
1	--	--	--	--
2	--	--	373.41	728.84
3	147.02	1195.15	447.35	546.66
4	--	--	--	--
5	862.35	948.96	783.31	557.87
6	--	1809.05	2212.73	1223.36
7	2870.77	2176.57	1732.34	2252.04
8	438.53	386.02	474.35	476.85
9	874.52	735.50	699.57	675.09
10	--	--	--	--
11	284.14	761.96	758.38	518.47
12	--	--	--	--
AVG.	912.89	1144.75	935.18	872.40

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1981

	LOCATION/STATION		
MONTH	MIDDLE HAVASU 22B	LOWER HAVASU 23A	PARKER DAM 24
1	--	--	--
2	--	--	--
3	896.39	467.74	633.59
4	--	--	--
5	1002.90	435.10	544.91
6	375.88	219.97	389.64
7	1636.52	1521.66	2306.35
8	691.53	649.93	769.76
9	--	--	971.57
10	--	--	--
11	508.76	444.71	627.80
12	--	--	--
AVG.	852.00	623.19	891.95

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1982

LOCATION/STATION

MONTH	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B
1	--	--	--	--	--	--
2	--	134.08	179.23	193.31	174.26	184.61
3	439.95	282.73	114.93	195.61	161.42	216.36
4	--	--	--	--	--	--
5	--	--	--	--	--	--
6	--	--	--	--	--	--
7	--	--	--	--	--	--
8	--	--	--	--	--	--
9	--	--	--	--	--	--
10	--	--	--	--	--	--
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	439.95	208.41	147.08	194.46	167.84	200.49

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1982

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1		--
2		110.12
3		182.75
4		--
5		--
6		--
7		--
8		--
9		--
10		--
11		--
12		--
AVG.		146.44

Appendix Table G. (Cont.)

PHYTOPLANKTON PRODUCTIVITY
(MG C/M-2/DAY)
1982

	LOCATION/STATION		
MONTH	INNER LVB2 BC2	MIDDLE LVB BC5	BOULDER BASIN BC8
1	--	--	--
2	56.83	293.96	674.67
3	448.88	1378.25	248.13
4	1805.29	3032.53	664.41
5	3210.26	2454.15	283.61
6	10624.22	1684.46	320.76
7	4056.95	1582.83	410.93
8	3410.71	1691.01	347.22
9	3387.93	292.26	307.49
10	1922.02	1116.63	497.78
11	144.83	453.26	387.56
12	155.50	419.75	260.58
AVG.	2656.67	1309.01	400.29

Appendix Table H. Monthly or average monthly temperatures at the surface in reservoir inflow and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982.

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	9.94	10.47	--	10.77	--	11.02
4	16.90	14.88	14.58	16.09	15.49	15.26
5	15.57	15.99	15.18	15.89	--	16.35
6	19.92	22.51	20.99	20.98	21.87	21.45
7	27.64	26.58	26.45	27.06	27.64	27.06
8	24.78	26.14	25.70	25.47	26.13	25.80
9	21.25	24.82	25.06	25.22	24.80	24.94
10	--	19.50	19.50	19.41	19.50	19.50
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	19.43	20.11	21.07	20.11	22.57	20.17

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	10.60	--	--	10.98	10.51	11.01	10.91	9.40
4	19.40	16.92	--	16.22	14.08	15.82	15.18	9.30
5	15.20	17.34	--	16.73	15.88	16.43	15.54	12.80
6	26.40	23.59	--	22.69	21.36	23.48	22.31	8.70
7	28.60	26.06	26.99	26.26	25.49	25.89	25.74	11.70
8	23.60	26.20	--	25.64	25.04	26.30	24.77	12.60
9	24.00	24.58	23.73	24.95	24.20	25.51	24.58	--
10	13.00	19.20	--	19.50	19.00	19.00	18.61	10.50
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	20.10	21.98	25.36	20.37	19.45	20.43	19.71	10.71

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--	--	--
2	10.50	10.60	11.16	12.73	13.03	12.94	12.94	--	--	--	--
3	12.99	14.31	14.15	14.35	14.45	14.95	13.90	21.20	14.11	13.67	--
4	16.96	18.36	18.49	18.38	18.27	16.64	16.44	23.00	18.43	17.45	17.83
5	17.77	22.73	23.00	22.48	21.40	20.91	19.91	--	21.12	20.41	20.56
6	20.85	26.84	27.34	27.03	26.61	26.34	25.30	28.90	28.31	27.19	25.22
7	19.00	27.64	30.49	29.92	29.81	28.30	28.08	26.70	30.63	29.93	29.57
8	17.77	26.54	28.59	28.50	28.48	27.97	28.10	28.60	29.61	29.32	29.03
9	15.68	24.78	25.98	25.69	26.29	26.39	26.61	25.50	26.35	26.31	26.65
10	12.92	18.87	19.02	20.34	20.64	20.54	20.57	19.00	19.96	20.51	20.64
11	--	--	--	--	17.76	17.96	17.69	--	16.86	17.38	17.54
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	16.05	21.19	22.02	22.16	21.67	21.29	20.95	24.70	22.82	22.46	23.38

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION		
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	--
2	--	--
3	18.00	14.44
4	24.00	18.44
5	--	20.79
6	30.10	27.36
7	25.70	29.47
8	29.60	29.13
9	29.50	26.06
10	19.50	18.85
11	--	15.85
12	--	--
AVG.	25.20	22.27

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	15.20	13.55	13.67	--	13.73	13.90	14.08
2	15.40	13.06	13.10	--	13.30	12.96	13.10
3	16.40	14.87	14.19	--	14.20	13.91	13.79
4	23.10	18.31	17.81	--	16.52	16.68	17.26
5	22.15	22.16	22.08	21.85	21.87	20.33	19.20
6	27.50	26.36	25.72	25.94	25.67	24.94	23.23
7	27.35	28.25	28.32	27.89	28.04	27.16	26.00
8	25.75	28.70	28.60	28.37	28.20	27.40	27.58
9	24.75	27.05	26.53	26.85	26.97	25.75	26.60
10	19.80	20.56	20.53	20.47	20.57	20.59	20.60
11	15.30	16.60	16.80	17.09	17.09	17.46	17.45
12	13.00	13.50	13.50	13.50	13.50	--	--
AVG.	20.48	20.25	20.07	22.74	19.97	20.10	19.90

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
	LOCATION/STATION						
1	--	--	--	--	--	--	--
2	--	13.25	13.83	13.40	12.58	12.40	13.30
3	12.80	12.61	12.99	14.77	14.97	11.70	13.60
4	--	--	--	--	--	--	--
5	13.00	13.38	15.18	20.09	20.78	18.30	16.00
6	12.50	13.71	20.39	21.08	21.40	20.47	17.10
7	13.10	14.09	24.33	26.82	26.80	23.69	18.35
8	13.40	14.33	22.66	30.35	30.12	29.21	19.00
9	12.70	.13.28	23.16	24.05	24.29	22.11	16.20
10	--	--	--	--	--	--	--
11	12.50	13.01	14.10	16.46	16.50	16.00	16.50
12	--	--	--	--	--	--	--
AVG.	12.86	13.46	18.33	20.88	20.93	19.23	16.26

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1981

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	11.90	13.00	--	13.40	--	13.32	--
3	14.50	14.80	16.03	16.29	17.04	16.93	16.57	16.30
4	--	--	--	--	--	--	--	--
5	16.60	17.20	19.88	20.84	21.60	21.80	21.76	-1.00
6	18.40	19.30	22.92	23.40	23.48	23.40	22.14	21.60
7	19.55	20.24	26.82	26.45	27.23	27.82	26.81	24.75
8	20.20	20.50	27.88	27.93	29.58	29.99	30.48	25.90
9	--	--	--	--	--	--	24.21	23.50
10	--	--	--	--	--	--	--	--
11	15.70	15.70	16.14	16.40	17.50	17.88	18.70	19.00
12	--	--	--	--	--	--	--	--
AVG.	17.49	17.09	20.38	21.88	21.40	22.97	21.75	21.84

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	8.55	8.90	--	8.70	8.87
2	5.30	7.95	8.40	9.10	9.05	8.85
3	9.00	9.20	8.90	8.35	9.10	9.00
4	9.80	10.06	9.76	9.80	10.00	10.32
5	--	15.88	15.25	14.80	16.50	18.20
6	19.70	19.41	20.10	21.46	21.66	21.16
7	26.30	24.54	24.57	26.87	25.74	25.80
8	25.83	26.57	26.70	27.76	27.67	27.16
9	18.13	23.97	23.90	23.96	24.98	24.79
10	--	17.33	17.51	17.90	18.40	18.50
11	--	--	--	--	13.36	13.50
12	--	12.30	12.60	12.70	--	--
AVG.	16.29	15.98	16.05	17.27	16.83	16.92

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA'CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	8.75	1.80	8.65	8.70	8.70	8.40	8.00
2	--	9.10	7.96	8.70	8.65	9.20	9.85	8.00
3	--	--	9.80	9.25	9.20	8.60	8.90	8.00
4	12.50	10.00	10.50	9.50	9.50	9.92	9.46	8.50
5	--	17.80	18.15	17.05	17.15	16.90	16.65	12.00
6	--	22.55	22.65	22.19	20.22	21.93	19.29	7.00
7	29.23	27.09	28:37	26.10	24.47	--	24.00	12.20
8	25.45	26.89	26.52	27.87	26.51	27.28	26.40	10.00
9	19.15	24.38	24.19	24.58	23.90	24.27	23.40	10.20
10	10.85	18.07	16.95	18.38	17.70	18.19	17.59	9.30
11	--	--	--	13.43	12.76	13.70	13.10	--
12	--	--	--	--	--	--	--	9.20
AVG.	19.44	18.29	16.69	16.88	16.25	15.87	16.09	9.31

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	8.58	8.10	8.95	11.85	12.48	12.00	12.00	12.00	10.55	--	11.50
2	10.10	10.91	11.40	11.98	12.60	12.90	12.27	18.50	12.00	11.60	11.50
3	10.65	13.45	13.45	13.70	13.50	13.60	13.00	19.00	13.29	13.15	13.00
4	14.04	15.46	15.39	16.68	14.21	14.50	14.00	15.00	13.71	13.41	14.00
5	13.85	18.51	19.35	19.51	19.00	17.99	17.30	27.20	18.52	17.97	16.99
6	18.75	25.82	26.20	25.83	25.95	25.61	25.14	29.30	26.14	25.65	24.03
7	17.79	25.86	27.40	27.06	27.31	26.59	26.04	31.70	28.79	27.83	26.05
8	17.73	29.09	30.10	29.97	29.94	29.41	--	29.60	30.11	29.70	28.20
9	17.17	27.88	28.09	28.10	28.79	28.60	28.30	25.80	28.67	28.66	27.62
10	14.39	22.36	22.69	23.02	22.96	22.69	22.29	21.10	22.57	22.80	22.30
11	10.72	15.23	15.83	17.77	17.93	17.89	17.50	--	16.17	16.79	16.90
12	10.00	11.32	11.14	13.99	14.15	14.19	13.82	14.10	12.99	13.29	13.35
AVG.	13.65	18.67	19.17	19.96	19.90	19.66	18.33	22.12	19.46	20.08	18.79

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	11.00	9.50
2	20.00	11.73
3	18.50	13.93
4	13.50	15.03
5	27.50	19.14
6	32.60	26.06
7	32.10	27.79
8	26.40	29.63
9	28.20	28.45
10	22.20	21.99
11	--	15.50
12	10.90	12.36
AVG.	22.08	19.26

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	10.00	11.00	11.00	11.50	12.00	12.15	12.00
2	16.00	12.00	12.00	12.20	12.20	12.00	12.50
3	16.00	13.85	13.89	13.94	13.83	13.90	13.20
4	17.50	15.21	15.15	15.16	15.14	14.98	15.00
5	19.50	18.44	18.44	18.40	18.34	17.73	17.30
6	26.80	27.30	27.23	26.85	26.59	24.69	22.67
7	28.13	28.53	28.48	26.62	28.39	26.60	24.54
8	27.50	29.45	29.42	29.37	29.23	28.05	25.90
9	25.00	29.41	29.35	29.29	28.92	28.20	27.91
10	19.00	22.18	22.20	22.40	22.30	22.05	22.19
11	15.00	17.10	17.30	17.60	17.58	17.49	17.40
12	10.40	13.50	13.60	14.03	14.07	14.20	14.10
AVG.	19.24	19.83	19.84	19.78	19.88	19.34	18.73

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	12.00	11.50	11.18	9.65	9.59	9.51	9.50
2	--	--	--	--	--	--	--
3	11.74	11.98	12.15	13.31	13.51	13.70	13.50
4	12.30	12.86	13.88	16.13	16.62	16.19	15.50
5	12.50	13.25	18.45	21.12	21.10	18.40	--
6	--	--	--	--	--	--	--
7	12.92	13.79	25.98	26.88	27.02	23.24	20.00
8	13.10	14.12	27.87	29.02	29.29	28.70	18.50
9	--	20.85	24.12	23.72	23.19	19.76	17.00
10	13.13	13.35	13.89	17.41	18.57	18.00	17.00
11	13.38	13.31	13.21	13.58	14.90	14.60	14.50
12	12.60	13.00	12.50	11.60	12.30	12.17	12.90
AVG.	12.63	13.80	17.32	18.24	18.61	17.43	15.33

Appendix Table H. (Cont.)

PHYSICAL DATA
TEMPERATURE
(DEGREES CENTIGRADE)
1982

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	9.00	9.13	8.77	9.26	9.04	9.00	9.35	9.50
2	--	--	--	--	--	--	10.58	--
3	11.50	12.50	12.78	14.18	14.09	14.46	15.05	13.05
4	15.50	15.82	17.87	18.54	18.93	18.91	18.09	18.00
5	16.04	16.61	21.87	22.61	23.11	23.20	22.34	--
6	17.26	18.00	25.51	25.49	25.20	26.29	25.17	25.20
7	21.13	20.72	26.97	27.01	28.24	28.96	28.93	26.50
8	20.18	19.71	27.49	27.80	28.74	28.97	28.99	27.00
9	--	18.91	23.08	23.60	24.37	25.15	24.34	23.00
10	--	17.90	18.41	18.46	18.96	18.93	19.44	19.00
11	14.25	14.03	14.40	14.40	14.93	15.37	15.83	15.00
12	12.11	11.80	12.00	11.95	12.24	12.74	13.11	13.00
AVG.	15.22	15.92	19.01	19.39	19.80	20.18	19.27	18.93

Appendix Table I. Monthly or average monthly pH at the surface in reservoir inflows and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982.

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*        PHYSICAL DATA       *
*             PH             *
*           (STD)            *
*            1981            *
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	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	8.35	8.26	--	8.35	--	8.21
4	7.92	8.51	8.52	8.32	8.28	8.35
5	8.33	8.37	8.57	8.63	--	8.71
6	7.48	7.72	8.18	8.30	8.26	8.38
7	8.28	8.61	8.63	8.68	8.63	8.59
8	8.20	8.41	-	8.49	8.58	8.54
9	7.91	8.33	8.55	8.54	8.56	8.64
10	--	8.31	8.20	8.13	8.20	8.27
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	8.07	8.31	8.44	8.43	8.42	8.46

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	8.34	--	--	8.31	8.06	8.22	8.30	7.80
4	8.21	8.63	--	8.36	8.29	8.38	8.35	8.02
5	8.28	8.80	--	8.68	8.62	8.71	8.63	7.94
6	9.03	8.12	--	8.30	8.35	8.27	8.29	7.15
7	8.20	8.60	8.28	8.50	8.31	8.40	8.40	7.82
8	7.06	8.72	--	8.62	8.58	8.54	8.61	7.79
9	8.27	8.32	8.41	8.58	8.48	8.61	8.56	--
10	8.20	8.18	--	8.19	8.35	8.40	8.40	7.50
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	8.20	8.48	8.34	8.44	8.38	8.44	8.44	7.72

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

	LOCATION/STATION										
MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--	--	--
2	8.25	8.34	8.26	8.19	8.22	8.03	8.08	--	--	--	--
3	8.46	8.44	8.44	8.29	8.28	8.35	8.45	7.77	8.17	8.35	--
4	8.43	8.35	8.36	8.33	8.36	8.38	8.40	7.79	8.33	8.34	8.34
5	8.43	8.22	8.36	8.41	8.38	8.53	8.51	--	8.42	8.48	8.52
6	8.39	8.24	8.26	8.28	8.28	8.36	8.40	7.63	8.30	8.26	8.33
7	8.21	8.42	8.38	8.42	8.42	8.27	8.20	7.81	8.35	8.29	8.31
8	8.10	8.51	8.42	8.50	8.61	8.35	8.30	7.70	8.25	8.32	8.43
9	8.20	8.45	8.40	8.41	8.41	8.23	8.24	--	8.19	8.22	8.21
10	8.28	8.42	8.45	8.36	8.29	8.24	8.22	8.00	8.37	8.30	8.21
11	--	--	--	--	--	--	--	--	8.27	8.18	8.16
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	8.30	8.37	8.37	8.35	8.36	8.30	8.31	7.78	8.29	8.30	8.31

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	--
2	--	--
3	7.86	8.38
4	7.84	8.24
5	--	8.37
6	7.57	8.17
7	7.53	8.30
8	7.73	8.44
9	---	8.20
10	8.10	8.35
11	--	8.00
12	--	--
AVG.	7.77	8.27

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	7.88	8.17	8.14	--	8.19	8.07	8.03
2	8.04	8.30	8.27	--	8.14	8.24	8.23
3	8.01	8.39	8.62	--	8.06	8.24	8.33
4	7.89	8.77	8.75	--	8.43	8.50	8.33
5	7.79	8.51	8.48	8.47	8.46	8.44	8.49
6	7.71	8.31	8.55	8.58	8.45	8.47	8.42
7	7.67	8.51	8.47	8.56	8.53	8.44	8.30
8	7.84	8.56	8.62	8.62	8.53	8.51	8.35
9	7.72	8.40	8.40	8.33	8.29	8.20	8.18
10	7.91	8.32	8.30	8.34	8.30	8.29	8.25
11	7.72	8.08	8.12	8.21	8.05	7.94	8.02
12	7.60	8.00	8.00	8.00	8.00	--	--
AVG.	7.81	8.36	8.39	8.39	8.29	8.30	8.27

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	7.79	7.45	8.09	8.10	8.12	--
3	8.05	8.03	8.09	8.16	8.41	8.51	8.49
4	--	--	--	--	--	--	--
5	7.82	8.02	7.96	7.73	8.03	8.32	8.10
6	7.82	7.79	8.26	8.15	8.17	8.23	7.92
7	8.03	8.11	8.37	8.35	8.39	8.34	7.93
8	8.07	8.12	8.41	8.39	8.49	8.51	7.22
9	8.00	7.94	8.46	8.50	8.40	8.37	7.60
10	--	--	--	--	--	--	--
11	7.70	7.80	7.98	8.40	8.29	8.05	8.19
12	--	--	--	--	--	--	--
AVG.	7.93	7.95	8.12	8.22	8.29	8.31	7.92

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1981

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	8.58	8.52	--	8.45	--	8.39	--
3	8.17	8.29	8.26	8.33	8.34	8.33	8.24	8.24
4	--	--	--	--	--	--	--	--
5	8.23	8.23	7.95	7.98	7.94	7.91	7.97	7.75
6	8.10	8.12	8.01	8.06	8.01	8.00	7.98	7.90
7	8.04	8.08	8.33	8.33	8.35	8.30	8.24	8.03
8	7.99	8.12	8.42	8.49	8.46	8.43	8.46	8.11
9	--	--	--	--	--	--	7.99	7.50
10	--	--	--	--	--	--	--	--
11	8.00	8.00	8.16	8.14	8.24	8.19	8.14	8.00
12	--	--	--	--	--	--	--	--
AVG.	8.09	8.20	8.24	8.22	8.26	8.19	8.17	7.93

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	8.00	8.00	--	7.80	7.80
2	7.71	7.74	7.71	7.82	7.82	7.79
3	8.10	8.00	7.80	8.00	7.87	8.20
4	8.21	8.20	8.20	8.10	7.80	7.80
5	--	8.06	8.02	8.27	8.69	8.79
6	6.45	8.12	8.29	8.51	8.26	8.72
7	7.80	8.53	8.16	7.39	8.03	8.10
8	7.71	8.37	8.52	8.37	8.22	8.24
9	7.58	8.05	7.91	8.02	8.00	8.05
10	--	7.78	7.78	7.61	7.55	7.71
11	--	--	--	--	7.97	8.06
12	--	8.18	7.97	7.90	--	--
AVG.	7.65	8.09	8.03	8.00	8.00	8.11

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	7.85	7.80	7.80	8.00	7.90	7.90	--
2	--	7.68	7.46	7.42	7.67	7.64	7.69	8.40
3	--	--	8.00	8.00	7.90	7.81	7.78	--
4	8.05	7.80	7.91	7.90	7.80	7.64	7.80	8.10
5	--	8.48	8.29	8.44	8.83	8.43	8.27	--
6	--	8.54	8.41	8.42	8.65	8.43	8.41	7.30
7	7.73	7.82	8.08	7.70	8.24	--	8.45	7.61
8	7.78	8.43	8.37	7.91	8.35	8.20	8.33	7.01
9	7.43	7.83	7.95	7.94	8.00	7.97	8.33	7.33
10	7.93	7.28	7.50	7.45	7.76	7.91	8.00	7.40
11	--	--	--	7.99	7.94	7.66	7.84	--
12	--	--	--	--	--	--	--	8.01
AVG.	7.78	7.97	7.97	7.91	8.10	7.96	8.07	7.65

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	8.52	8.60	8.70	8.60	8.60	8.47	7.93	--	8.19	--	8.05
2	8.50	8.50	8.52	8.35	8.30	8.30	8.40	8.90	8.66	8.65	8.60
3	7.95	7.95	7.95	7.93	7.90	7.90	7.73	--	8.03	7.81	7.78
4	7.81	7.82	7.81	7.83	7.85	7.90	--	8.05	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	8.10	7.45	8.15	8.15	8.12
7	8.14	8.48	8.34	8.30	8.19	8.26	8.22	7.80	8.16	8.21	8.26
8	7.97	8.42	8.37	8.39	8.23	8.06	--	7.45	7.96	8.10	8.08
9	8.11	8.37	8.31	8.27	8.18	8.08	8.23	7.48	8.11	8.28	8.21
10	8.23	8.26	8.20	8.27	8.37	8.41	8.04	6.99	8.23	8.32	8.19
11	8.46	8.43	8.39	8.28	8.30	8.26	8.16	--	8.17	8.14	8.11
12	8.57	8.56	8.71	8.54	8.54	8.38	8.32	7.98	8.51	8.58	8.31
AVG.	8.22	8.34	8.33	8.27	8.24	8.20	8.13	7.76	8.22	8.25	8.17

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	8.20
2	8.40	8.68
3	--	7.94
4	8.10	--
5	--	--
6	7.48	7.96
7	7.73	8.35
8	7.62	8.17
9	8.82	8.11
10	7.19	8.29
11	--	8.15
12	8.30	8.57
AVG.	7.95	8.24

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	7.90	8.10	8.10	8.10	8.00	7.93	7.90
2	8.30	8.50	8.50	8.60	8.60	8.50	8.50
3	7.45	7.73	7.77	7.95	7.93	7.75	7.76
4	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--
6	7.09	8.04	8.22	8.15	8.47	8.51	8.29
7	7.37	8.36	8.47	7.88	8.43	8.38	8.46
8	7.23	8.41	8.44	8.46	8.34	8.32	8.32
9	7.38	8.46	8.38	8.34	8.40	8.35	8.26
10	7.38	8.47	8.26	8.22	8.18	8.56	8.46
11	7.52	8.18	8.13	8.17	8.04	8.04	7.85
12	7.86	8.53	8.44	8.39	8.46	8.27	8.28
AVG.	7.55	8.28	8.27	8.23	8.28	8.26	8.21

Appendix Table I. (Cont.)

PHYSICAL DATA
PH
(STD)
1982

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	7.70	7.76	7.78	8.05	8.06	8.10	8.03
2	--	--	--	--	--	--	--
3	7.78	7.77	7.83	7.80	7.82	8.00	7.90
4	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--
7	8.03	8.25	8.62	8.56	8.53	8.43	7.10
8	7.60	8.71	8.72	8.60	8.49	8.44	8.64
9	--	7.73	7.75	7.68	7.91	7.65	7.89
10	7.66	7.76	7.80	8.09	8.19	7.84	7.78
11	7.54	7.57	7.77	7.93	7.94	7.97	7.74
12	7.60	7.71	7.86	8.04	8.20	8.28	7.71
AVG.	7.70	7.91	8.02	8.09	8.14	8.09	7.85

Appendix Table I. (cont.)

PHYSICAL DATA
PH
(STD)
1982

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	8.14	8.15	8.07	8.12	8.09	8.10	8.02	8.00
2	--	--	--	--	--	--	8.31	--
3	7.65	7.75	7.71	7.68	7.70	7.67	7.72	7.77
4	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--
6	7.73	8.23	8.14	8.29	8.18	8.26	8.18	8.02
7	7.73	7.50	8.26	7.98	8.34	8.36	7.98	7.20
8	8.55	8.50	8.74	8.55	8.77	8.65	8.89	7.77
9	--	7.80	8.17	8.05	8.03	8.03	7.47	7.41
10	--	8.01	7.95	8.07	7.97	7.95	7.93	8.11
11	7.85	7.79	7.83	7.89	7.89	7.85	7.77	7.81
12	7.94	7.91	7.89	7.87	7.97	7.87	7.94	8.00
AVG.	7.94	7.96	8.08	8.05	8.10	8.08	8.02	7.79

Appendix Table J. Monthly or average monthly dissolved Oxygen concentrations at the surface in reservoir inflow and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982.

PHYSICAL DATA
OXYGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	9.28	--	--	8.84	8.58	8.26	8.62	5.88
4	8.41	10.31	--	9.33	9.71	10.06	9.86	6.98
5	7.75	8.43	--	8.27	8.44	8.34	8.23	7.96
6	15.53	7.95	--	8.72	9.41	9.06	9.01	7.61
7	7.16	7.81	6.60	7.53	6.85	7.22	7.35	6.96
8	6.11	6.70	--	7.07	6.44	7.09	7.27	6.85
9	7.75	6.52	7.83	7.80	7.02	7.00	7.27	--
10	--	7.83	--	7.20	7.91	8.29	8.45	--
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	8.85	7.94	7.21	8.09	8.04	8.17	8.26	7.04

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--	--	--
2	10.48	11.32	10.66	9.84	10.11	9.92	9.16	--	--	--	--
3	9.80	9.76	9.97	10.16	9.50	9.35	9.63	6.59	9.02	9.30	--
4	9.45	9.12	9.39	9.07	9.23	9.30	9.54	6.40	9.66	9.54	9.14
5	8.93	8.48	8.14	8.49	9.20	9.39	9.20	--	8.72	8.49	9.05
6	8.94	8.27	8.17	8.23	9.07	8.87	8.97	7.60	8.78	8.71	8.46
7	8.16	8.10	7.95	7.71	7.86	7.82	7.74	5.60	7.26	7.30	7.54
8	7.60	8.73	8.11	8.18	7.95	7.74	7.64	5.83	7.35	7.78	7.45
9	7.04	7.58	6.61	7.16	6.81	8.51	8.58	--	7.76	8.29	8.18
10	10.86	9.91	9.60	8.88	8.72	8.28	8.24	8.80	9.29	8.31	8.19
11	--	--	--	--	7.95	7.06	8.24	--	8.62	8.24	8.68
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	9.03	9.03	8.73	8.63	8.64	8.62	8.69	6.80	8.50	8.44	8.34

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1981

	LOCATION/STATION	
MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	--
2	--	--
3	7.92	9.25
4	7.37	9.17
5	--	8.18
6	--	9.40
7	5.98	7.94
8	6.20	9.00
9	--	7.79
10	8.80	9.37
11	--	9.48
12	--	--
AVG.	7.25	8.84

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1981

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	9.29	10.56	9.19	--	9.91	8.68	9.08
2	9.38	11.36	9.17	--	8.98	9.26	8.75
3	8.60	10.60	11.60	--	9.95	9.50	9.41
4	7.37	12.18	11.21	--	9.81	8.91	9.04
5	6.47	10.17	10.68	10.85	10.62	9.54	8.86
6	7.10	13.52	14.66	12.88	11.38	9.80	10.34
7	6.77	10.03	10.60	9.74	9.26	7.57	8.13
8	6.56	9.08	9.29	8.98	8.20	7.70	7.23
9	6.91	9.26	9.05	9.20	8.87	8.05	8.20
10	8.61	8.56	8.67	8.48	8.28	8.40	8.27
11	6.65	8.58	8.82	8.52	8.33	7.84	7.71
12	8.40	10.80	10.98	11.04	9.92	--	--
AVG.	7.67	10.39	10.33	9.96	9.46	8.66	8.64

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1981

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	8.15	8.69	9.87	10.15	10.23	--
3	8.18	7.39	8.18	10.15	9.81	10.34	9.97
4	--	--	--	--	--	--	--
5	6.48	7.85	8.34	8.66	8.49	8.35	8.50
6	8.72	8.83	11.59	9.85	9.71	9.70	9.32
7	6.78	7.90	9.31	8.59	8.75	9.41	8.32
8	--	--	--	--	--	--	6.64
9	7.10	7.98	10.29	9.75	9.89	9.85	8.31
10	--	--	--	--	--	--	--
11	8.00	9.07	11.02	11.64	10.90	9.79	9.05
12	--	--	--	--	--	--	--
AVG.	7.54	8.17	9.63	9.79	9.67	9.67	8.59

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1981

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	10.58	9.94	--	9.78	--	9.58	--
3	10.12	10.38	9.88	10.15	10.06	10.44	10.05	8.75
4	--	--	--	--	--	--	--	--
5	8.70	9.10	8.09	8.15	7.87	7.75	7.84	6.99
6	9.66	10.14	9.57	9.78	9.45	9.32	9.48	8.82
7	7.39	7.58	8.80	9.14	8.86	8.67	9.27	7.59
8	7.03	7.36	8.35	9.03	8.71	8.58	9.01	6.38
9	--	--	--	--	--	--	7.31	5.70
10	--	--	--	--	--	--	--	--
11	10.00	11.13	10.91	10.30	10.84	10.29	9.95	9.50
12	--	--	--	--	--	--	--	--
AVG.	8.82	9.47	9.36	9.43	9.37	9.18	9.06	7.68

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	9.35	8.35	--	8.85	8.72
2	10.53	9.90	9.56	9.54	9.01	7.98
3	--	--	--	--	--	--
4	9.98	9.90	9.60	9.46	9.99	9.99
5	--	--	--	--	--	--
6	7.15	8.01	9.04	8.26	8.73	8.22
7	6.57	8.30	7.51	6.92	7.12	7.06
8	6.27	7.65	7.78	8.15	7.87	7.67
9	7.38	6.40	5.76	5.91	6.27	5.79
10	--	6.64	6.95	7.38	6.80	6.75
11	--	--	--	--	7.13	6.90
12	--	7.71	8.16	7.68	--	--
AVG.	7.98	8.21	8.08	7.91	7.97	7.67

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	9.45	10.80	9.00	9.05	9.35	9.70	--
2	--	9.23	8.99	8.78	9.40	--	8.73	9.50
3	--	--	--	--	--	--	--	--
4	9.30	10.20	10.36	11.38	9.98	9.71	9.22	9.90
5	--	--	--	--	--	--	--	--
6	--	8.90	9.08	8.24	8.32	8.84	8.43	8.10
7	6.16	7.75	7.63	7.50	7.47	--	8.42	5.30
8	5.70	7.27	7.46	7.25	8.08	8.12	7.82	5.70
9	6.45	6.07	6.65	5.85	6.53	6.22	6.90	6.10
10	6.95	6.22	6.76	5.95	6.19	6.20	7.18	6.40
11	--	--	--	6.41	7.35	8.35	8.81	--
12	--	--	--	--	--	--	--	7.20
AVG.	6.91	8.14	8.47	7.82	8.04	8.11	8.36	7.28

Appendix Table J. (Cont.)

****
PHYSICAL DATA
OXYGEN
(MG/L)
1982
****

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	9.61	12.00	10.06	9.92	9.81
3	10.18	10.67	9.89	10.20	9.82	9.69	10.11	--	9.88	10.00	10.14
4	9.97	10.33	10.47	10.81	10.20	9.92	10.36	9.77	9.68	9.90	10.55
5	9.47	9.51	9.20	9.12	9.41	9.59	8.19	--	7.92	8.06	8.16
6	--	--	--	--	--	--	8.99	8.01	8.71	8.69	9.35
7	8.49	8.99	8.60	8.69	8.18	7.81	8.35	10.94	7.79	7.70	8.02
8	8.07	8.01	7.89	7.68	7.49	6.56	--	5.50	7.41	7.69	7.56
9	7.72	7.25	6.79	7.68	7.14	7.32	7.78	7.98	6.65	7.33	7.17
10	8.78	8.42	8.40	8.04	8.20	7.61	8.15	8.60	7.79	7.76	7.79
11	10.44	8.92	9.21	8.39	9.66	8.29	8.69	--	8.56	8.69	8.29
12	10.04	9.26	9.83	8.15	9.70	8.40	8.58	9.03	9.19	10.07	9.19
AVG.	9.24	9.04	8.92	8.75	8.87	8.35	8.88	9.10	8.51	8.71	8.73

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	--
2	9.00	10.19
3	--	9.91
4	9.80	9.08
5	--	7.50
6	6.70	8.32
7	7.06	8.38
8	8.20	7.82
9	8.20	6.26
10	8.60	8.18
11	--	9.08
12	9.78	9.43
AVG.	8.42	8.56

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

LOCATION/STATION

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	--	--	--	--	--	--	--
2	9.90	9.11	9.15	8.93	8.90	8.98	9.12
3	9.20	9.65	9.64	10.93	10.78	9.45	9.96
4	8.40	11.74	11.38	10.36	9.47	9.90	9.86
5	8.05	10.61	10.47	10.67	10.45	9.74	8.58
6	5.51	12.88	11.10	9.03	8.87	8.74	9.90
7	5.64	10.17	10.02	8.35	8.78	8.28	8.89
8	5.34	8.63	8.72	8.69	8.24	7.45	8.36
9	6.09	8.81	8.31	8.12	7.98	7.58	7.56
10	7.32	8.47	8.18	7.99	7.74	7.49	7.55
11	8.85	7.70	7.52	7.67	7.68	7.71	7.45
12	9.60	8.44	8.37	8.34	8.18	8.11	8.00
AVG.	7.63	9.65	9.35	9.01	8.82	8.49	8.66

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	8.65	8.68	9.01	10.16	10.41	10.67	10.90
2	--	--	--	--	--	--	--
3	8.64	8.85	9.08	9.77	10.05	10.01	10.00
4	8.40	8.50	8.72	9.41	8.88	8.67	8.45
5	8.82	8.84	9.39	9.16	9.09	8.93	--
6	--	--	--	--	--	--	--
7	8.43	8.90	9.37	8.74	8.63	9.43	7.00
8	7.70	6.37	6.81	6.76	6.92	7.21	6.80
9	--	8.46	8.13	8.17	8.22	6.61	7.00
10	7.73	8.93	9.27	9.29	9.24	8.43	7.80
11	6.80	6.90	7.99	8.44	8.10	8.43	9.20
12	6.84	8.13	8.56	9.51	9.75	10.31	9.70
AVG.	8.00	8.26	8.63	8.94	8.93	8.87	8.54

Appendix Table J. (Cont.)

PHYSICAL DATA
OXYGEN
(MG/L)
1982

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
	LOCATION/STATION							
1	11.08	11.20	10.71	10.76	10.70	10.63	10.43	11.00
2	--	--	--	--	--	--	9.09	--
3	10.17	10.42	9.90	9.79	9.80	9.61	9.46	9.45
4	7.88	7.96	8.43	8.73	8.38	8.23	8.16	8.10
5	9.16	9.10	8.72	8.89	8.46	8.56	8.58	--
6	8.02	8.46	8.64	8.59	8.66	8.58	8.78	7.50
7	8.87	8.70	10.99	10.88	10.84	10.41	10.23	7.10
8	7.13	7.07	7.81	7.91	8.22	8.12	7.78	6.50
9	--	7.69	8.31	8.40	8.46	8.68	6.11	6.30
10	--	9.36	9.18	8.79	8.74	8.09	7.59	8.45
11	8.75	8.49	8.67	8.58	8.47	8.58	8.10	8.70
12	9.46	8.86	9.20	9.08	8.96	8.81	9.68	9.95
AVG.	8.94	8.85	9.14	9.13	9.06	8.93	8.67	8.31

Appendix Table K. Monthly or average monthly conductivities at the surface in reservoir inflow and discharges and in 0-5 m integrated depths for main reservoir stations in the Colorado River during 1981 and 1982.

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

	LOCATION/STATION					
MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	738	710	--	706	--	670
4	1130	820	710	710	672	680
5	1000	904	901	718	--	739
6	438	560	820	770	696	689
7	989	704	614	770	760	726
8	1545	965	785	770	760	750
9	1560	1010	891	778	755	756
10	--	1150	1100	909	850	790
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	1057	852	831	766	748	725

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

LOCATION/STATION

MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--
3	945	--	--	639	670	690	687	940
4	1030	626	--	670	680	700	696	910
5	430	696	--	733	743	754	761	880
6	460	665	--	662	680	681	700	820
7	835	651	821	680	700	690	699	870
8	920	710	--	682	740	709	710	800
9	880	743	764	680	736	710	715	--
10	700	830	--	770	798	790	780	880
11	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--
AVG.	775	703	792	689	718	715	718	871

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--	--	--
2	950	955	968	1023	1025	1068	1121	--	--	--	--
3	1000	1005	938	951	980	1020	1058	1450	1103	1078	--
4	1144	1037	999	1018	976	985	1049	3280	1114	1117	1035
5	1050	1060	1080	1060	1040	1038	1062	--	1139	1139	1095
6	991	1021	1025	1025	1087	1121	1122	2200	1102	1111	1100
7	1060	1036	1057	1049	1056	1070	1097	3240	1151	1139	1105
8	978	992	1008	1006	1009	1066	1089	3480	1159	1129	1108
9	1000	1072	1114	1053	1080	1105	1153	--	1247	1211	1190
10	955	1005	984	1001	1005	1082	1080	2400	1256	1200	1165
11	--	--	--	--	1002	1039	1049	--	1136	1118	1089
12	--	--	--	--	--	--	--	--	--	--	--
AVG.	1014	1020	1019	1020	1026	1059	1088	2675	1156	1138	1117

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	--	--
2	--	--
3	2240	1237
4	1960	1318
5	--	1427
6	4160	1181
7	3100	1254
8	3040	1212
9	--	1324
10	3950	1313
11	--	1170
12	--	--
AVG.	3075	1270

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
	LOCATION/STATION						
1	3180	1157	1150	--	1149	1150	1145
2	3250	1189	1175	--	1180	1171	1179
3	3340	1151	1119	--	1110	1102	1099
4	3210	1287	1197	--	1123	1109	1107
5	2995	1448	1305	565	560	1085	1119
6	2930	1618	1336	1193	1171	1189	1162
7	2965	1362	1304	1238	1201	1115	1110
8	2860	1299	1227	1167	1137	1099	1109
9	3005	1298	1302	1234	1222	1245	1191
10	3190	1100	1201	1152	1077	1165	1132
11	2660	1169	1162	1169	1156	1147	1152
12	3300	1250	1250	1250	1250	--	--
AVG.	3073	1277	1227	1121	1111	1143	1136

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

LOCATION/STATION

MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	--	--	--	--	--	--	--
2	--	1220	1220	1208	1217	1230	1075
3	1090	1092	1090	1095	1100	1119	1110
4	--	--	--	--	--	--	--
5	1090	1093	1093	1108	1116	1115	1090
6	1030	1100	1100	1100	1100	1120	1125
7	1095	1106	1122	1124	1143	1138	1100
8	1020	1060	1079	1089	1100	1099	1090
9	1080	1119	1181	1200	1183	1133	1180
10	--	--	--	--	--	--	--
11	1125	1135	1150	1147	1125	1125	1200
12	--	--	--	--	--	--	--
AVG.	1082	1115	1129	1133	1135	1134	1121

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1981

	LOCATION/STATION							
MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	--	--	--	--	--	--	--	--
2	--	1220	1230	--	1230	--	1235	--
3	1120	1120	1120	1121	1128	1123	1122	1140
4	--	--	--	--	--	--	--	--
5	1110	1110	1121	1127	1119	1129	1130	1140
6	1120	1120	1120	1124	1120	1119	1115	1120
7	1110	1111	1158	1151	1152	1145	1160	1155
8	1090	1090	1099	1099	1102	1106	1094	1110
9	--	--	--	--	--	--	1155	1150
10	--	--	--	--	--	--	--	--
11	1200	1241	1220	1200	1250	1200	1200	1150
12	--	--	--	--	--	--	--	--
AVG.	1125	1144	1152	1137	1157	1137	1151	1137

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

LOCATION/STATION

MONTH	COLORADO RIVER 1	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	933	867	--	774	757
2	980	904	845	824	804	779
3	1050	859	815	794	784	763
4	1100	808	610	580	910	909
5	--	525	678	835	795	765
6	425	455	521	708	752	804
7	660	484	460	531	556	631
8	1058	712	550	510	530	571
9	1137	827	730	570	530	528
10	--	880	800	630	600	570
11	--	--	--	--	670	660
12	--	840	792	700	--	--
AVG.	915	747	697	668	700	703

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

	LOCATION/STATION							
MONTH	SAN JUAN RIVER 2	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5	GLEN CANYON DAM OUTFLOW 7
1	--	708	731	705	728	721	721	950
2	--	720	984	744	779	714	709	1000
3	--	--	910	759	744	734	734	800
4	960	880	920	870	899	909	882	1150
5	--	725	474	764	766	763	760	--
6	--	614	360	768	800	780	780	860
7	522	386	388	709	711	--	780	830
8	795	392	540	640	684	770	780	860
9	720	529	582	560	600	710	750	870
10	780	580	590	549	570	670	750	820
11	--	--	--	630	670	729	750	--
12	--	--	--	--	--	--	--	850
AVG.	755	614	647	699	722	750	763	899

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

LOCATION/STATION

MONTH	SEPARATION RAPIDS 9	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY RIVER 12	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	808	865	1025	1015	1035	1100	1100	2850	1100	--	1100
2	975	945	945	1100	1100	1100	1150	3700	1250	1200	1150
3	1100	1141	1120	1120	1150	1150	1200	1950	1306	1250	1200
4	1195	1200	1191	1130	1110	1150	1200	2710	1250	1200	1175
5	1119	1180	1187	1190	1158	1170	1197	2300	1254	1285	1210
6	1010	1030	1028	1020	1010	1017	990	2800	1043	1028	1000
7	950	1039	1049	1040	1038	1050	1030	2940	1084	1063	1046
8	915	989	990	990	990	1020	--	2670	1100	1090	1070
9	1020	1029	1030	1030	1049	1080	1100	3280	1160	1138	1094
10	995	1007	1010	1009	1010	1022	1080	2980	1160	1135	1100
11	871	955	979	984	980	1000	1020	--	1060	1050	1014
12	892	933	941	980	980	1000	1040	2890	1090	1090	1040
AVG.	987	1026	1041	1050	1055	1071	1100	2824	1154	1139	1099

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

LOCATION/STATION

MONTH	VIRGIN RIVER 13	VIRGIN BOWL 13A
1	2800	1135
2	2900	1295
3	2200	1476
4	2700	1500
5	2200	1609
6	3910	1196
7	4250	1119
8	3000	1133
9	--	1220
10	3270	1253
11	--	1129
12	2245	1113
AVG.	2947	1264

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

	LOCATION/STATION						
MONTH	LAS VEGAS WASH LVW	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	3100	1025	1035	1050	1050	1150	1100
2	3600	1225	1225	1225	1225	1225	1200
3	3450	1386	1361	1310	1310	1250	1250
4	3200	1317	1300	1250	1274	1220	1210
5	3450	1439	1501	1375	1338	1219	1220
6	2660	1214	1186	1131	1129	1110	1100
7	2640	1248	1221	1046	1106	1063	1070
8	2667	1265	1241	1173	1130	1087	1061
9	2690	1210	1199	1188	1176	1140	1140
10	2720	1209	1210	1170	1160	1120	1120
11	2740	1100	1100	1100	1090	1070	1070
12	3060	1100	1090	1090	1085	1080	1080
AVG.	2998	1228	1222	1175	1172	1144	1135

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

	LOCATION/STATION						
MONTH	HOOVER DAM OUTFLOW 17	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19	DAVIS DAM OUTFLOW 20
1	1250	1250	1225	1250	1225	1225	1220
2	--	--	--	--	--	--	--
3	1262	1250	1250	1250	1252	1250	1260
4	1250	1279	1267	1225	1225	1300	1300
5	1200	1225	1250	1250	1210	1180	--
6	--	--	--	--	--	--	--
7	1060	1064	1090	1090	1090	1086	1110
8	1070	1050	1077	1080	1080	1080	1100
9	--	1083	1080	1070	1070	1060	1070
10	1077	1090	1086	1110	1107	1100	1070
11	1050	1070	1060	1070	1079	1080	1050
12	1050	1068	1070	1070	1080	1089	1090
AVG.	1141	1142	1145	1146	1141	1145	1141

Appendix Table K. (Cont.)

PHYSICAL DATA
CONDUCTIVITY
(MICRO-MHOS/CM)
1982

LOCATION/STATION

MONTH	NEEDLES 21	TOPOCK 22	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24	PARKER DAM OUTFLOW 25
1	1200	1225	1250	1250	1250	1300	1276	1300
2	--	--	--	--	--	--	1058	--
3	1250	1271	1275	1275	1275	1275	1297	1290
4	1300	1300	1295	1290	1300	1297	1259	1300
5	1178	1200	1200	1200	1223	1225	1225	--
6	1070	1080	1100	1100	1100	1110	1103	1090
7	1130	1130	1135	1132	1133	1140	1150	1110
8	1090	1090	1087	1090	1100	1100	1103	1110
9	--	1087	1090	1090	1090	1090	1094	1090
10	--	1078	1089	1080	1080	1080	1078	1070
11	1095	1110	1110	1100	1100	1100	1095	1090
12	1090	1105	1100	1100	1100	1103	1100	1130
AVG.	1155	1152	1157	1155	1159	1165	1153	1158

Appendix Table L. Monthly or average monthly Secchi depth measurements for main reservoir stations in the Colorado River during 1981 and 1982.

PHYSICAL DATA
SECCHI
(M)
1981

	LOCATION/STATION				
MONTH	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	--	--	--	--	--
2	--	--	--	--	--
3	4.00	--	4.75	--	8.00
4	4.50	6.25	9.00	12.25	11.00
5	2.00	4.50	7.25	--	6.75
6	.25	2.25	3.75	2.75	3.00
7	1.75	2.20	4.50	6.10	6.00
8	2.50	4.50	4.75	5.25	7.00
9	2.25	3.00	4.25	5.25	4.25
10	3.75	4.50	4.50	5.75	7.75
11	--	--	--	--	--
12	--	--	--	--	--
AVG.	2.63	3.89	5.34	6.23	6.72

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

LOCATION/STATION

MONTH	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	--	10.00	13.25	12.50	11.75
4	2.75	--	12.25	9.75	10.00	10.25
5	7.00	--	5.50	8.75	8.75	9.00
6	3.75	--	2.50	4.75	3.75	7.25
7	2.25	.50	6.50	4.50	4.00	3.25
8	4.00	--	6.25	7.25	6.25	6.25
9	2.00	.90	4.00	7.00	6.00	6.75
10	2.25	--	5.50	9.75	6.50	7.00
11	--	--	--	--	--	--
12	--	--	--	--	--	--
AVG.	3.43	.70	6.56	8.13	7.22	7.69

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

LOCATION/STATION

MONTH	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	--	--	--	--	--	--	--	--	--
2	1.25	4.75	8.75	10.25	12.25	16.50	--	--	--
3	3.75	5.75	6.75	12.00	18.00	15.75	4.13	7.00	--
4	4.75	6.50	7.50	8.25	14.75	15.00	1.75	10.25	17.50
5	2.50	4.50	4.25	3.00	4.50	7.75	2.25	5.00	7.75
6	5.25	5.25	4.60	5.75	6.75	9.00	2.75	5.00	7.75
7	2.75	6.00	7.50	9.25	8.50	12.25	1.75	4.50	8.50
8	3.00	4.25	5.75	7.00	10.50	10.75	.50	4.25	9.25
9	3.25	5.50	5.50	8.00	9.75	10.50	1.50	4.00	7.50
10	3.25	4.50	5.25	9.00	11.00	12.00	1.75	4.25	11.25
11	--	--	--	13.25	13.75	10.75	4.00	4.50	8.25
12	--	--	--	--	--	--	--	--	--
AVG.	3.31	5.22	6.21	8.58	10.98	12.03	2.26	5.42	9.72

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

LOCATION/STATION

MONTH	VIRGIN BOWL 13A
1	--
2	--
3	6.75
4	3.25
5	.75
6	3.75
7	1.50
8	1.25
9	1.25
10	1.75
11	3.50
12	--
AVG.	2.64

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

LOCATION/STATION

MONTH	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 16
1	9.10	10.10	--	14.50	13.00	16.90
2	10.25	12.75	--	10.75	12.00	11.00
3	3.63	2.10	--	5.25	10.75	13.25
4	.50	1.25	--	7.63	12.25	15.00
5	1.03	1.88	3.08	3.50	6.63	7.00
6	.80	.75	1.00	3.50	8.00	5.75
7	1.38	1.50	1.88	3.50	7.38	5.00
8	.95	1.18	2.00	3.13	7.13	7.50
9	1.35	1.55	2.60	2.90	3.75	4.10
10	4.80	6.50	7.80	7.25	9.00	10.25
11	7.75	9.00	8.25	10.00	11.50	11.50
12	8.00	9.00	7.25	9.00	--	--
AVG.	4.13	4.80	4.23	6.74	9.22	9.84

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

LOCATION/STATION

MONTH	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19
1	--	--	--	--	--
2	6.50	4.50	4.00	7.75	6.75
3	7.25	6.75	4.25	6.75	9.00
4	--	--	--	--	--
5	-1.00	10.25	8.25	11.50	10.25
6	9.75	3.75	4.00	7.00	7.25
7	10.13	2.75	3.50	5.25	3.88
8	11.75	2.75	3.00	5.00	4.75
9	2.00	1.50	3.50	3.75	3.50
10	--	--	--	--	--
11	6.00	3.80	3.50	3.50	3.90
12	--	--	--	--	--
AVG.	7.63	4.51	4.25	6.31	6.16

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1981

	LOCATION/STATION				
MONTH	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24
1	--	--	--	--	--
2	3.75	--	3.75	--	2.25
3	4.00	4.00	4.50	5.00	5.25
4	--	--	--	--	--
5	4.00	3.25	4.50	6.75	-1.00
6	4.75	5.00	6.50	7.25	7.25
7	2.75	3.25	2.88	3.13	2.88
8	2.75	3.00	3.75	4.00	3.75
9	--	--	--	--	2.25
10	--	--	--	--	--
11	1.25	1.25	1.75	1.75	1.25
12	--	--	--	--	--
AVG.	3.32	3.29	3.95	4.65	3.55

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	HITE 1A	GOOD HOPE MESA 1B	HALLS CROSSING 3	SLICK ROCK CANYON 3D	ESCALANTE 3A
1	4.30	--	--	8.75	11.00
2	6.00	7.00	7.25	7.75	7.25
3	7.25	9.00	8.50	7.00	7.00
4	4.25	7.25	8.25	11.75	12.25
5	--	1.00	6.00	8.00	6.50
6	.75	1.75	7.00	7.75	9.75
7	1.75	4.50	7.50	8.75	9.50
8	2.00	3.00	5.75	10.00	7.25
9	1.75	4.25	3.50	3.75	4.50
10	4.25	4.50	4.75	6.25	7.00
11	--	--	--	8.25	7.00
12	2.75	5.25	3.50	--	--
AVG.	3.51	4.75	6.20	8.00	8.09

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

	LOCATION/STATION					
MONTH	ZAHN BAY 2A	CLAY HILLS CROSSING 2B	CHA CANYON 3B	RAINBOW MARINA 3C	PADRE BAY 4	WAHWEAP 5
1	5.25	.50	6.75	9.75	8.50	--
2	6.25	.25	7.25	8.00	10.75	8.75
3	--	--	11.00	9.75	10.25	12.25
4	7.50	.50	11.00	12.50	9.50	9.25
5	4.50	.50	4.25	7.25	9.25	7.50
6	6.25	1.50	13.25	10.25	15.75	14.50
7	2.50	2.00	8.25	8.50	--	6.75
8	--	1.50	4.75	4.75	5.25	5.25
9	2.00	1.25	12.50	5.25	7.00	6.00
10	5.00	3.75	8.25	6.25	--	10.75
11	--	--	6.50	6.00	9.75	7.50
12	--	--	--	--	--	--
AVG.	4.91	1.31	8.52	8.02	9.56	8.85

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	GODS POCKET 8A	GRAND WASH 8B	ICEBERG CANYON 9A	GREGG BASIN 9B	TEMPLE BASIN 10	VIRGIN BASIN 11	MUDDY ARM 12A	OVERTON 12B	ECHO BAY 12C
1	1.00	2.75	7.75	7.25	9.75	10.80	1.25	--	8.25
2	1.25	4.00	7.75	10.25	12.00	13.88	4.00	13.00	12.00
3	2.75	7.00	6.75	10.25	19.75	15.75	1.50	6.50	13.25
4	1.00	1.75	1.50	3.75	11.50	13.00	1.00	2.00	8.75
5	1.00	2.25	3.25	5.75	11.50	10.75	.80	3.75	12.00
6	--	5.75	6.00	6.50	6.25	10.00	2.75	7.25	7.25
7	4.50	7.00	5.50	8.00	14.25	12.50	1.75	8.75	10.75
8	4.75	5.50	7.50	7.00	9.75	--	1.75	5.25	6.75
9	4.00	4.50	5.00	7.00	8.25	10.00	2.00	7.00	9.50
10	4.00	4.50	4.75	6.00	12.75	9.75	--	7.25	10.00
11	--	8.25	10.50	15.75	13.25	13.75	1.75	4.25	11.00
12	2.75	3.25	9.25	10.00	15.50	12.75	4.25	6.75	10.75
AVG.	2.70	4.71	6.29	8.13	12.04	12.08	2.07	6.52	10.02

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	VIRGIN BOWL 13A
1	1.75
2	5.75
3	6.75
4	.90
5	.90
6	2.00
7	2.50
8	.50
9	.65
10	2.25
11	1.50
12	6.00
AVG.	2.62

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	INNER LVB2 BC2	INNER LVB3 BC3	INNER LVB4 BC4	MIDDLE LVB BC5	BOULDER BASIN BC8	BLACK CANYON 15
1	8.40	9.75	10.50	9.00	10.25	9.75
2	9.25	12.50	14.00	15.00	10.75	12.00
3	5.25	6.75	4.00	3.25	--	15.75
4	2.25	5.25	6.25	9.00	11.75	14.50
5	2.25	2.25	4.25	3.00	12.25	15.00
6	1.75	2.50	4.75	4.75	9.25	6.00
7	2.25	2.92	5.00	5.42	11.00	9.25
8	1.75	1.86	2.63	3.44	7.69	5.75
9	1.75	3.50	2.50	3.25	6.50	6.25
10	2.75	2.50	5.25	5.25	9.25	7.00
11	8.50	7.50	9.00	9.00	14.75	10.75
12	9.25	10.25	8.75	9.00	10.75	11.25
AVG.	4.62	5.63	6.41	6.61	10.38	10.27

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	MONKEY HOLE 17A	ELDORADO CANYON 17B	LITTLE BASIN 17C	COTTONWOOD BASIN 18	KATHERINES LANDING 19
1	5.50	--	6.75	8.25	4.25
2	--	--	--	--	--
3	7.38	5.63	5.75	9.88	8.00
4	10.50	8.50	7.50	--	11.40
5	9.50	6.50	8.25	10.00	7.25
6	--	--	--	--	--
7	7.38	4.00	6.63	6.75	5.88
8	.25	3.00	4.50	4.75	3.25
9	1.75	2.00	4.25	4.75	4.25
10	5.75	3.75	4.25	4.75	3.75
11	7.25	3.00	3.00	4.50	3.50
12	5.50	3.25	3.50	3.75	4.25
AVG.	6.08	4.40	5.44	6.38	5.58

Appendix Table L. (Cont.)

PHYSICAL DATA
SECCHI
(M)
1982

LOCATION/STATION

MONTH	UPPER HAVASU 22A	MIDDLE HAVASU 22B	HAVASU CITY 23	LOWER HAVASU 23A	PARKER DAM 24
1	1.00	1.00	1.75	1.75	1.25
2	--	--	--	--	1.75
3	1.13	1.50	2.38	3.13	3.75
4	2.25	4.50	6.00	9.00	11.75
5	3.00	3.25	4.75	6.50	9.50
6	4.25	4.00	6.35	5.25	6.00
7	2.75	3.25	4.00	4.00	4.75
8	1.75	2.00	2.50	3.00	3.25
9	2.00	1.75	1.75	2.50	2.25
10	--	1.00	1.25	1.75	1.75
11	1.00	1.00	1.25	1.25	1.25
12	1.25	1.00	1.50	1.75	1.50
AVG.	2.04	2.20	3.04	3.63	4.06